

# THE Festivus

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*Octopus bimaculoides* study

Fossil volutes and cowries

New *Jaspidiconus* from Brazil

Deforestation and Cuban land snails

Quarterly Publication of the San Diego Shell Club



# THE FESTIVUS

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Club meetings are held on the third Thursday or Saturday of the month, except April, September and December, at either 7:30 p.m. in Room 104, Casa del Prado, Balboa Park, San Diego, or at 12:00 noon at other locations as noticed on the Club's website. Due to the pandemic General Meetings for February through April were cancelled and no meeting minutes were recorded.

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## FRONT COVER:

Photograph of *Octopus bimaculoides* Pickford & McConaughey (1949) in Mission Bay, San Diego, California, by Paul Tuskes. (Cover artistic credit: Rex Stilwill).

## MISSION STATEMENT

The San Diego Shell Club was founded in 1961 as a non-profit organization for educational and scientific purposes. More particularly to enjoy, study and promote the conservation of Mollusca and associated marine life through lectures, club meetings and field trips. Our membership is diverse and includes beginning collectors, scientists, divers, underwater photographers and dealers.

*THE FESTIVUS* is the official quarterly publication of the San Diego Shell Club, Inc. and is issued as part of membership dues in February, May, August and November. *The Festivus* publishes articles that are peer reviewed by our volunteer Scientific Peer Review Board, as well as articles of general interest to malacologists, conchologists, and shell collectors of every level. Members of the Peer Review Board are selected to review individual articles based upon their chosen field of expertise and preference. Available by request or on our website are:

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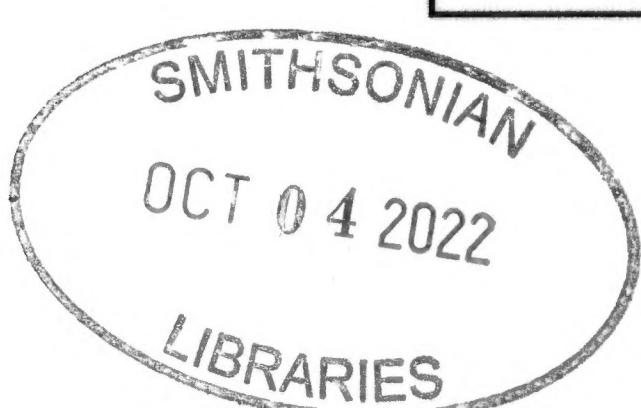
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## The Diet of *Octopus bimaculoides* in Mission Bay, California (Mollusca: Cephalopoda)

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**ABSTRACT** A year-long survey of *Octopus bimaculoides* Pickford & McConaughey (1949) dens in three different subtidal habitats was conducted in Mission Bay, California. Habitat complexity and stability were positively associated with prey species richness, species abundance, and den availability. Collectively, 38 species of bivalves and 22 species of gastropods were recorded from octopi debris fields. Two species of bivalve at each site comprised approximately 60% or greater of the bivalves in the debris fields. Bivalves species represented 85% of the take, the remainder being gastropods. With the exception of the bubble snail, most gastropods were drilled, while most bivalves were not. Crustacean remains were infrequently found in debris fields. Prey species in other phyla may have been consumed, but their remains were not found in the debris fields.

**KEY WORDS** Diet, habitat complexity, habitat stability, prey species, *Octopus bimaculoides*

### INTRODUCTION

Although *Octopus bimaculoides* can be a common inshore species, details regarding the natural diet of this species are lacking. This paper reports *in situ* findings in three varied habitats of Mission Bay, San Diego, California. The goals of this study were to: (1) determine the prey species found in debris fields of octopi dens in different subtidal habitats, (2) evaluate the contribution of the various prey species to the diet of *O. bimaculoides*, (3) identify which mollusks are pulled open vs. drilled, (4) compare and contrast habitat complexity, stability, and diet in these different subtidal environments, and (5) a review of literature relevant to the life history of *O. bimaculoides*. The findings reported may not be inclusive of all potential prey species, but rather those species who's remains were found in the debris fields of the octopi dens.

Two similar appearing species of octopi occur in southern California, *Octopus bimaculoides*

Pickford & McConaughey 1949 and *Octopus bimaculatus* Verrill, 1883. They were believed to be one species until differences in their reproductive biology were noted. *Octopus bimaculoides* (Figure 1) produces larger eggs



Figure 1. *Octopus bimaculoides* in Mission Bay.

(9-17 mm) and upon hatching the small octopi take up residence in the benthic community, while the eggs of *O. bimaculatus* are small (2-4 mm) and upon hatching the larvae enter the planktonic community (Pickford & McConaughey 1949, Forsythe & Hanlon 1988a, Ambrose 1988).

Dominguez-Contreras *et. al.* (2018) evaluated the distribution and genetic structure of three species of *Octopus* in the northern Gulf of California and the Pacific side of northwestern Baja California, Mexico. Two species had planktonic larvae *O. bimaculatus* and *O. hubbsorum* Berry 1953 and one species *O. bimaculoides* had direct development. They found that populations of *O. bimaculoides* had low genetic diversity and higher levels of kinship, compared to the two species with planktonic larvae. In essence, *O. bimaculoides* puts all of its eggs in one basket, while the other two species spread their genetic material far and wide. The difference in reproductive strategies has many ecological and evolutionary implications.

Based on both field observations and laboratory studies Forsythe & Hanlon (1988a & 1988b), published details regarding growth, reproduction, effects of temperature on development, and skin display patterns. *Octopus bimaculoides* has a life span of approximately 1-1.5 years and reproduces only once. Depending upon the location, peak reproduction is between October and May. Lang (1986) reported female *O. bimaculoides* *in situ* were brooding eggs on a year-round basis, but did not identify a peak period. Growth rate is temperature dependent especially for developing embryos and juveniles. Females lay clusters of eggs on hard surfaces in protected rocky dens, and during that time, they often do not feed, and die shortly after their eggs hatch. I have observed *O. bimaculoides* as it goes

through senescence, it becomes less efficient in its actions, skin may begin to sluff, the animal coloration is dull, and often seen fully exposed during the day. The first time I observed post reproductive individuals in decline was alarming.

Walderon *et. al.* (2011) demonstrated chemoreceptors associated with the tentacles of *O. bimaculoides* have a role in detecting food, and the presence and even the sex of a nearby conspecific member of the population. Ramirez & Oakley (2015) removed patches of skin from *O. bimaculoides*, and found that, photo sensitive proteins activated chromatophores resulting in color change without interaction of the eyes or brain. The biological importance may be that it allows portions of the animal, such as a tentacle that may exit the den before the mantle, to quickly adapt to the surroundings. Derby *et. al.* (2007) suggested the ink of mollusks such as cephalopods protect these organisms with a collection of chemicals that cause sensory disruption to the predator, combined with other compounds associated with decaying matter. In the case of the octopus, such disruption, even if momentary, may allow the octopus to escape.

The moderate size, ease of laboratory culture and behavioral traits have made the genus *Octopus* the subject of many studies, which are mentioned only for awareness and include: social behavior, learning, problem solving, senescence, digestive enzymes, pigmentation, chemo-receptors, toxins, muscle function, sucker dynamics, regeneration of limbs, reproduction, anatomy, brain and nervous system function, parasites and laboratory culture.

Under natural conditions *O. bimaculoides* is a corpuscular/nocturnal predator. Upon capturing prey, the octopus returns to the safety of the den to consume the meal. Afterwards, the shell is discarded at the entrance, while others may be

incorporated into the den opening, especially if the den is at the rock/sand interface. The debris field outside the dens has been termed a midden, implying a large collection of shells. How many shells constitute a midden is not universally defined. Ambrose (1983) in detailed studies of *O. bimaculatus*, suggested that 20 shells constitute a midden and therefore concluded middens were not formed by that species. I use the term debris field, as it accounts for variable numbers of shells associated with each den. In this study, debris field of *O. bimaculoides* contained 5 to over 30 shells.

Wodinsky (1969) described four steps in the process of an octopus capturing and consuming its prey: (1) prey recognition/selection (2) pull open or drill the prey (3) inject toxins yes/no (4) consume prey and discard. Between steps one and two I would add; (1.1) attack and subdue and (1.2) move to less exposed location to process prey (usually the den). Wodinsky (1969) conducted experiments related to prey selection and drilling, and provides a generic review of literature associated with each of the four steps.

#### **Abbreviations.**

MB = Mainer's Basin

MP = Mainer's Point

UW = Underwater

VC = Ventura Cove

#### **METHODS**

A Nikon Cool pic underwater camera was used to document observations and habitat. All sites were surveyed bi-monthly for one year. Each site was surveyed using SCUBA and dead shells and crustaceans associated with the dens were placed in prelabeled sample bags. Intact dead gastropods associated with the dens were collected. Only bivalves with both valves still attached were collected and scored. Intact bivalves could confirm if they had been drilled

or not and suggested they were recently preyed upon by octopi. Bivalves that were separated or broken were not collected or scored. Shells were lightly washed, dried, identified, measured, and returned to the bay, but not in the area of the study sites. In addition to the scheduled sampling, numerous monthly visits to the sites were made to make general observations.

The wet weight of notable prey species was determined as follows. Bivalves and gastropods that contributed significantly to the diet were collected alive and frozen briefly. The following day shells were measured and allowed to thaw. Bivalves were removed from their shell by cutting the abductor muscle and the animal was placed on a paper towel to absorb surface moisture. Any portion of the abductor left in the shell was removed and added to the material on the paper. Gastropods were treated in a similar fashion, but removed entirely by either fragmenting the shell, or removing it intact with forceps. Animals that were damaged during this process were discarded. Any bits of shell attached to the animal were removed, as was external mucus and the operculum. Once the appearance of the extracted animal was matte rather than wet, they were removed from the paper and weighed on a CCT series scale and the weight rounded to the nearest 0.1 gram. The data was recorded and the pan of the scale cleaned and the scale zeroed in preparation for the next sample.

#### **Study Sites - Southwest Mission Bay. (see Figure 2)**

Mariner's Point MP (Figure 3) has extensive rocky rip-rap that lines the shore to a depth of 4-5 m and terminates on the clean sand bottom with occasional patches of eel grass (*Zostera marina* Linnaeus, 1753). The rocky habitat supports various marine algae, and in turn

herbivorous gastropods. Tidal currents are present.

Mariner's Basin MB (Figure 4) is located on the west side of Mariner's Point. The area is characterized as sand with little sediment, there are few scattered rocks and eel grass is dominant and present year-round. Currents are minimal and the depth on the shelf is 2-3 meters. The dredged portion of the basin is typically 6-7 meters, and was not part of the study area.

Ventura Cove VC (Figure 5). The study area was north of the designated swimming area and west of the main Channel. The habitat is sparse, with silty-sand, and patchy eel grass during the summer, that is absent or greatly reduced during the winter. No rocks are present and daily tidal currents are present. The survey depth was 4-5 meters.

## RESULTS

Table 1 provides a summary of each study site and includes habitat assessment, relative abundance of octopi, total number of shelled mollusk species collected in debris fields, and percent of bivalves and gastropods recovered from each of three habitats.

**Bivalves.** Table 2 summarizes the data collected for each of three sites, and lists the author of each species, and the page in Coan *et. al.* (2000), where photos, distribution and descriptions for each species can be found. A total of 3,102 bivalves were collected, representing 38 species associated with octopi dens. The most commonly consumed bivalves were the California Jackknife Clam *Tagelus subteres* which accounted for 46% to 53% of bivalves taken at all three sites. Bivalves such as *Chione undatella*, *Gari californica*, *Protothaca staminea*, *Saxadomus nuttalli*, *Trachycardium quadrangarium*, and *Tresus nuttallii* from

Mariner's Basin were slightly smaller than the same species found in debris fields at Mariner's Point. The size of *Tagelus subteres* and *Tagelus californianus* at both of those locations did not differ significantly.

**Gastropods.** Table 3 summarizes the data for each of three sites and lists the author for each gastropod species. The gastropods are illustrated in Berschauer & Clark 2019. Collectively 528 shells, representing 22 species of gastropods were associated with octopi dens. The bubble snail *Bulla gouldiana* was the only gastropod commonly consumed in all three habitats. At Mariner's Basin, the dietary preference of two octopi made the small purple olive *Callianax biplicata* (formally *Olivella*) the most frequently taken gastropod at that site. Another octopus targeted various species of moon snails.

Figure 8 provides estimates of biomass vs. size for various mollusks commonly consumed at the study sites. When looking at prey species of vastly different sizes, it may be important to also evaluate biomass when considering the overall contribution of a specific prey species to the diet of the predator.

## DISCUSSION

Anderson (2006) published a key to the west coast octopi species, which works well for animals that have been captured. Unfortunately, working *in situ*, with animals in their dens or den entrance, characters such as the configuration of the false-eyespot (ocelli), or the ratio of arm length to mantle size, are not visible. While diving and observing octopi in their dens, it was impossible to determine that only *O. bimaculoides* inhabited every den. When visible, they typically have a tentacle wrapped around their body just below their eyes (Figure 6). Any intrusive method to capture octopi would be destructive to both the habitat and den, and

potentially injurious to the animal. A cross section of octopi were captured for identification upon completion of this study and only *O. bimaculoides* were found.

In Mission Bay, *O. bimaculoides* is an opportunistic corpuscular/nocturnal hunter feeding primarily on bivalves, gastropods, and occasionally crustaceans. Only seven crab carapaces were found during the study, all but one was from Mariner's Point; they include four Yellow Crabs, *Cancer anthonyi* Rathbun, 1897 and three Red Rock crabs *Cancer productus* Randall, 1839. Based on frequent monthly observations, the crabs were uncommon at these sites. Other species of soft bodied invertebrates and fish may have been consumed but their remains were not found associated with the dens.

**Other Predators of Mollusks.** *Octopus bimaculoides* is one of many predators of mollusks in Mission Bay. Although only shells in the debris fields were evaluated, it was still necessary to identify shells that may have been preyed upon by other predators from those taken by the octopus.

In the area of the study sites, subtidal vertebrate predators that focus on mollusks included the Horn Shark *Heterodontus francisci* Girard, 1855, with a strong preference for the Speckled Scallop *Argopecten ventricosus*, and rays including the large Bat Ray *Mylobatis californica* T.H. Gill, 1865. I have observed bat rays working in the sand for bivalves, and taking Wavy Top Turban *Megastraea undosa* off rocks and over sand. Both of these predators crush the shells, and the remains are discarded, but shell fragments appear in their waste. Various species of crabs and the Spiny Lobster *Panulirus interruptus* J.W. Randall, 1840, also consume mollusks, but again, they break the shell to gain access. The spiny lobster, horn

shark and bat rays were observed at all three study sites.

Other predators of mollusks in the bay include the Giant Star Fish *Pisaster giganteus* Stimpson, 1857, but not observed at the three sites during this study, and numerous gastropods, especially *Forreria belcheri* Jousseaume 1850, *Pteropurpura festiva*, and three species of Naticidae. These species drill the shell or in the case of *F. belcheri* abrade the lip of the bivalve. Fortunately, the patterns are distinctive and easily distinguished from the drilling caused by this octopus. For these reasons, only intact bivalves that were still hinged and found in the debris field were scored.

**Habitat Complexity and Mollusks Consumed.** Habitat complexity and stability are critical factors that influence both octopi abundance and prey diversity. Mariner's Basin (MB) and Mariner's Point (MP) scored high, as no observable change to the habitat or food availability were observed during the survey period of one-year Table 1. Ventura Cove (VC) was scored low for stability, as virtually all of the eel grass cover is lost in the winter leaving a near barren sand habitat, and secondarily, the transient nature of the swimming *Argopecten ventricosus*. Figure 2 is a map of the southwestern portion of Mission Bay indicating the location of each study site. Figures 3-5 are underwater photos of the typical habitat associated with each of the three study sites.

In this study, instability of cover, lack of den sites and prey was reflected by the general absence of mature octopi in VC. The loss of eel grass in VC is an annual fall-winter event but, by late spring eel grass beds may reappear. The same pattern for eel grass loss and regrowth occurs in nearby Santa Barbara Cove. Results for MB may have been similar to those of VC, but the year-round persistence of dense eel grass

and occurrence of the occasion rock provide cover, den sites, and support additional prey species.

The extensive rocky habitat of Mariner's Point, supports a wide variety of algae, which in turn supports herbivorous gastropods and provides shelter and resources for other invertebrates and vertebrates. The rocky habitat is greatly reduced in MB and absent from VC. Surprisingly, only 19 species of bivalves were consumed by octopi in VC, while at both MB and MP 32 species were consumed at each. The nature of instability at VC does not explain why there were 40% fewer bivalve species found in the debris fields. The substrate in VC may be less suitable for a variety of clams than MP or MB. Tables 2 and 3 summarizes the species and numbers of bivalves and gastropods found in debris fields at each location. The number and types of mollusk species consumed is an indirect measure of habitat complexity. Those numbers also reflect both prey abundance (opportunity) and dietary preference (desirability). As habitat complexity decreased so did prey diversity and the relative abundance of octopi (Table 1).

**Mariner's Point MP** (Table 1, Figure 3) (54 species and 1,951 individuals). The habitat is dominated by rocky rip-rap debris. Octopus dens were located among the rocks or at the rock-sand interface. Thirty-two species of bivalves were consumed, representing 1,523 individuals collected in the debris fields (Table 2). The California Jackknife Clam *Tagelus subteres* represented 53% of all bivalves taken, followed by *Saxidomus nuttalli* 10.1% and *Gari californica* at 6.8% (Table 2). Bivalves collected in the debris fields represented 78% of the shells, gastropods the remainder.

Twenty-two species of gastropods (428 individuals) were collected at this site. The Bubble Snail, *Bulla gouldiana* (21%) and olive *Callianax biplicata* (35%) accounted for 56% of

the total number of gastropods taken (Table 3). The majority of the olives were consumed by only two octopi.

**Mariner's Basin MB** (Table 1, Figure 4) (40 species & 1,082 individuals). The habitat is sand dominated by eel grass year-round. Octopi dens were located among the roots of eel grass and under or between the occasional rock. Mariner's Basin had 32 species of bivalves, representing 1,020 individuals. *Tagelus subteres* accounted for 46.6% of the bivalves taken, followed by *Laevicardium substriatum* 11.6% and *Chione undatella* 10.1% (Table 2). No mature specimens of the larger bivalve species such as *Saxidomus* and *Semele*, were found in the debris fields, only juveniles which were typically opened without drilling. Although both MB and MP each had 32 species of bivalves in the debris field, only 21 of those species occurred in both locations.

Eight species of gastropods (62 individuals) were found associated with octopi dens. The primary gastropod taken was *Bulla gouldiana* 51.6%, followed by *Megastraea undosa* (16.1%) and *Tegula eiseni* (12.9%).

**Ventura Cove VC** (Table 1, Figure 5) (24 species & 597 individuals). The study area is dominated by silty-sand with transitory eel grass that is present during the summer but greatly reduced or absent during fall and winter. No rocks are present. The habitat has both low diversity and low stability.

Adequate den sites of reproductively active octopi are absent, as eggs must be attached to a hard surface. As a result, smaller octopi that use unique den opportunities (e.g. among eel grass roots, the occasional soda can, bottle, empty *Megastraea undosa* shells, hinged bivalves, potato chip bag partly buried, sponge and sand depression (Figure 6) were the norm. The

bivalves used for these mobile dens included *Anadara multicostata*, and large specimens of *Argopecten ventricosus*, and halves of *A. ventricosus* are used to shield the otherwise exposed portions of the octopus (Figure 7). Dens made in the sand appeared to be supported, at least around the openings, with shell debris, and were often partially covered with dead strands of eel grass buried in the sand. The dead buried eel grass was covered by shifting sand and provided a supportive matrix and probably the reason those sites were selected (Figure 6). Due to the lack of suitable den sites, mature octopi do not typically reside in this habitat.

A total of 559 bivalve shells were collected, representing 19 species. The prominent bivalves taken at this location are *Tagelus subteres* 49.2%, *Laevicardium substriatum* 17.2%, and *Argopecten ventricosus* 17.4%.

Although juvenile octopi are always present, larger adult animals were only observed when the speckled scallops were abundant in June. Speckled Scallop *A. ventricosus* is exceedingly mobile and a strong swimmer. The species is transient, but when present, 3-12 scallops/m<sup>2</sup> was typical. The scallops are not an easy target as they have a strong flight response, but at high densities not everyone moves fast enough. When scallops are present the number of octopi in VC increases and decreases sharply when the scallops move on. The scallops ranged in size from 13 to 65 mm in diameter, the average was 36 mm with a median of 45 mm. All scallops were opened by pulling, they were not drilled. A study by Lang (1986) of *O. bimaculoides* at Agua Hedionda Lagoon in Carlsbad, California found *A. ventricosus* to be the major prey item, and they were both drilled and pulled open. Although not stated, the scallop population must have been persistent, rather than transient as in VC.

Only five species of gastropods, representing 38 individuals were found associated with octopi dens. *Bulla gouldiana* represented 81.6% of the gastropods associated with dens (Table 3).

**Pull or Drill – Diet.** Bivalves are often pulled open; when that is unsuccessful, the shell may be drilled. Shelled gastropods are more likely to be drilled than bivalves but in either case this leaves the shells intact. There is no agreement as to how the genus *Octopus* drills. Octopi use their radula to bore through the shell; a process that may be augmented with chemicals secreted by the octopus (Wodinsky 1969, Steer & Semmens 2003, Anderson & Mather 2007). After the shell is penetrated, toxins from the posterior salivary gland are introduced, through the small opening, which induces paralysis, allowing the prey to be removed and consumed (Ghiretti 1960, Nixon *et. al.* 1980, Steer & Semmens 2003). The drilling activity had been assumed to be performed by the radula of the octopus, but in the case of *O. vulgaris*, Cuvier, 1797, Nixon *et. al.* (1980) removed the beak and radula and found that the octopus drilled the shell with a structure on the salivary gland. When the radula was left in-tact and the structure on the salivary gland removed, the octopus was unable to drill. The author is not aware of similar experiments with *O. bimaculoides* or *O. bimaculatus*, but it brings into question the drilling mechanism commonly attributed to these two species. It may be that various species have different methods for accomplishing the task of drilling prey. The external diameter of the hole drilled appears related to the thickness of the shell under attack. To penetrate the 3.5 mm thick base of a wavy top snail, the bore width on the surface of the shell was 3.5 mm; the bore hole diameter for *Tegula eiseni* with shell thickness of 0.7 to 1.4 mm ranged from 1.05 mm to 1.5 mm in diameter. Regardless of shell thickness, the final diameter of the hole, that opens into the

cavity of the prey, is approximately 0.3 mm. In their study of *O. vulgaris*, Nixon & Maconnachie (1988) reported the shape of the cavity drilled was influenced by characteristics of the shell, not the size of the octopus, which is consistent with current observations for *O. bimaculoides*.

Targeting bivalve or gastropod that do not require the octopus to expend time and energy to drill the shell would seem ideal. In the current study, the bivalve *Tagelus subteres* and the gastropod *Bulla gouldiana* are not drilled and accounted for the majority of bivalves and gastropods taken at each location. Anderson & Mather (2007) found that in laboratory conditions that *Enteroctopus dofleini* (Wulker, 1910) preferentially consumed bivalves that could be opened by pulling over those that had to be drilled. Dodge & Scheel (1999) working on the same species noted that crustaceans were routinely drilled, but bivalves were not; they also noted the composition of prey species differed based on the habitat.

**Gastropods.** With the exception of the *Bulla gouldiana*, all gastropod species in the debris were drilled to varying degrees. The four most commonly consumed gastropods were *Megastraea undosa*, *Callianax biplicata*, *Tegula eiseni* and *B. gouldiana*. and collectively these four species accounted for 81.3% of the 525 gastropod shells collected in debris fields.

*Tegula eiseni* was drilled 94.5% of the time. The body whorl was targeted 55.5% of the time, penultimate whorl 36%, base 5.5%. The olive *Callianax biplicata* is a small species, and although it lacks a notable operculum it can withdraw deep into the shell. Ninety-one percent of the olives in the debris fields had been drilled. Drilling occurred only on the penultimate and ultimate whorl, on the aperture side of the shell.

Wavy top turbans *Megastraea undosa* were not found in the debris field if they were smaller than 32 mm or greater than 101 mm (base diameter). Shells were drilled only on the aperture surface (73%) near the point of attachment for the muscular foot to the columella, the remaining 27% showed no physical damage.

**Bivalves.** Among the bivalves only six of the 38 species associated with the dens were periodically drilled, the majority were pulled open. *Protothaca staminea*, *P. laciniata*, *Semele decisa*, and *Leporimetis obesa* were infrequently drilled. Approximately 21% of the *Chione undatella* were drilled, typically near the lip, and drilling location was unrelated to the clam size.

The sixth species drilled was *Saxidomus nuttalli*, the juveniles were not drilled, larger individuals between 60-80 mm were drilled approximately 12% of the time while larger specimens 81-101 mm were drilled 71% of the time. Anderson *et al.* 2008 used five zones to describe the location where octopi drilled bivalves (umbo, posterior adductor, central, anterior adductor, and ventral). Based on these regions, successful drilling events on mature *S. nuttalli* occurred in the area of the unbo (75%), upper anterior adductor (7%), central (14.5%), posterior adductor zone (3.5%), ventral (none).

Bivalves such as *Argopecten*, *Chione*, *Laevicardium*, *Limaria*, *Donax*, *Trachycardium*, *Musculista*, and *Americardia* may be found on the surface of the sand, or in the case of *Chione*, *Protothaca* and *Donax* they may also be buried just below the surface. The California Jackknife clam *Tagelus subteres*, which is a significant component of the diet, is deeply buried in the sand except when feeding, as are *Saxidomus nuttalli* and *Tresus nuttallii*. Mature *Tresus nuttalli* can exceed 200 mm in length, but only

juveniles under 60 mm were associated with dens. How they capture these three species was not apparent. Having pursued those species with a shovel at other locations during low tide, I have only had success with *Tagelus*. The success of the octopi especially with *Saxidomus* and *Tresus* is impressive. The Rock Scallop *Crassadoma gigantea* that were consumed were juveniles prior to attaching to rocks.

#### Dietary Preferences and Avoidance.

Individual octopi are biased regarding prey selection, as they collect prey of a size that allows successful manipulation and subsequent consumption. For example, even though present, Wavy turbans smaller than 32 mm or larger than 105 mm were not found in the debris fields.

Three *O. bimaculoides* at MP exhibited strong preferences for specific gastropods. One octopus accounted for the majority of the moon snails consumed. Moon snails smaller than approximately 2.5 cm were not drilled, while larger individuals were consistently drilled on the ventral surface or the upper portion of the body whorls.

The vast majority of the olives were consumed by two octopi at MP. Considering the number of prey species available, targeting the smallest resource which had to be drilled, may represent individual dietary preference. The two dens accounted for approximately 76% of the 150 olive *Callianax biplicata* in debris fields at MP. Neither octopus fed exclusively on *C. biplicata* but the numbers taken were disproportional compared to their cohorts. Approximately 92% of the olives were drilled. Drilling occurred on both the lower half of the penultimate whorl and body whorl adjacent to the suture. In the other two habitats with more sand and olives, only 5 olives were recorded in debris fields (Table 3).

The two most commonly consumed gastropods were the Olive (155) and the Bubble Snail (153). In this situation, I question the value of using only capture data as a measure of dietary significance. On the surface, the data suggest that olives are an important food source, but only two octopi consumed 76% of the olives. This observation lead to an evaluation of prey biomass for various species that contributed notably to the octopi diet (see Numbers vs. Biomass).

**Species seemingly under-utilized.** Under-utilized prey species are defined here as species that were frequently observed in the habitat but seldomly found in the debris fields. The large Key Hole limpet *Megathura crenulata* is a common species, and the animal too large to withdraw under its shell. As such, it is potentially exposed directly to the bite of an octopus, yet the number taken indicates they are infrequently eaten. It is speculation, but all of the mollusks that are drilled or pulled open by the octopi have soft or relatively soft body tissue. The exposed foot of *M. crenulata* is very dense and tough, perhaps making it less palatable to octopi.

Evans (1980) reported finding thousands of dead Chestnut Cowries, *Neobernaya spadicea*, over the course of a few months off Laguna Beach, southern California. He collected 208 dead shells on one dive and reported that 89.4% had been drilled on the posterior inner lip, and believed that the remainder had also been eaten by octopi without drilling the shell.

At MP, live cowries were observed during nearly every dive, yet only one specimen was found in debris fields. Other predatory gastropods such as *Pteropurpura trialata*, *Pteropurpura festiva* and *Kelletia kelletii* although common, were absent or nearly so in the debris fields. The murex *Pteropurpura*

*festiva*, was often observed singly or in groups feeding with impunity on remains of meat on the muscle scar of large bivalves discarded near the den entrances by the octopus. Ambrose (1984) also noted under-utilization of certain prey species by *O. bimaculatus* and provided a list of prey species consumed in the field and laboratory.

**Numbers vs. Biomass.** Do numbers alone adequately represent the importance of a given prey species? To address this question, a follow-up study of prey biomass was undertaken. Approximately thirty live individuals of varying size were collected for each of eight species. The animals were removed from the shell and evaluated as described in the methods. The results are present in Figure 8. Some species such as *Saxidomus nuttalli*, and *Laevicardium substriatum*, which were notable food sources could not be live collected in sufficient numbers to generate meaningful information. Numerically, the small olive appears to be an important gastropod in the diet of the octopi. But, only two octopi accounted for 114 of the 150 olives taken at Mariner's Point. Considering the availability of prey, these two individuals demonstrated a strong personal dietary preference. Even if the 150 olives had been consumed randomly by the population at large, would the olive have been an important food source?

For discussion purposes, I am assuming that the food value of soft bodied mollusks is somewhat similar regardless of the species. Plotting wet weight of animal tissue against shell size provides an approximate relationship between biomass and prey size. Based on average size range of species collected in the debris fields, a rough estimate of biomass per prey species consumed can be generated. Figure 8 provides such data for eight species that were collected in sufficient number. The red dot on each graph

indicates the average size of the prey species found in the debris field of the octopi dens at MP. The average sized olive had a biomass of 0.37 gr, the average Jackknife clam *Tagelus subteres*, had a biomass of approximately 2.2 gr or nearly six times greater than the olive. Based on casual observation, filter feeding clams, the Bubble snail and olive probably have lower body weight to gut content than large algae feeding gastropods, such as *Megastraea undosa*. This disparity could be partially addressed by removing undigested gut contents and possible other non-consumable tissue, and then weighting and plotting the more edible protein source against shell size. I realize the limitations and the time involved in this approach, but it may better reflect the food value of a given species to the octopi.

## SUMMARY

Ambrose (1983, 1984) studied the diet and biology of *O. bimaculatus* off Santa Catalina Island in Southern California and evaluated midden formation, he reported that only 3% of the dens were associated with 5 or more shells in their debris field and he concluded that *O. bimaculatus* does not produce midden. There was no indication the octopi purposely removed the shells, and Ambrose attributed their disappearance to environmental factors and hermit crabs.

*Octopus bimaculoides* in the rocky habitat of outer Mission Bay do produce a debris field sufficiently large to be termed a midden. If all shells in the debris fields had been collected (regardless of condition) the count would have been much higher. It is only speculation, but large debris fields advertise the presence of the octopus, which may encourage conspecifics to look elsewhere for their next den, thereby preventing confrontations. Some octopi at MP had dens located 6-7 m from the nearest sand,

but the exterior of those dens was littered with bivalves, indicating they returned to their den with prey, prior to consumption. Based on the laboratory observations by Cigliano (1993) regarding den competition in *O. bimaculoides*, it may be that the most mature/dominant individual had dens in close proximity to the bivalve resource, and those much farther away, but still utilizing that resource, were less dominant. Large debris fields may come at a cost, if predators of the octopus selectively look for dens in the area of shell debris.

The composition of the debris field reflects the local environment, combined with prey availability and preference of the octopus. As such, dietary information from the study of debris fields in varied habitats continues to provide insight into the plasticity of the behavior, which allows the secretive octopus to be a successful predator of a wide array of prey species. I would not speculate that the diet of *O. bimaculatus* reported by Ambrose (1984) and the diet of *O. bimaculoides* reported here, reflects species differences, it is just as likely to reflect the dietary opportunity presented in different environments.

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Study Site	Habitat* Components	Habitat Stability/Complexity	Relative Octopi Density	Bivalve Species Consumed	Number Bivalve Found	Gastropod Species Consumed	Number Gastropod Found
Mariner's Point	Rock / algae / sand / eel grass	High High	High	32	1,523 78%	22	428 22%
Mariner's Basin	Eel grass / sand / rock / algae	High Moderate	Moderate	32	1,020 94.3%	8	62 5.7%
Ventura Cove	Sand / eel grass transient	Low Low	Low	19	559 94.1%	5	38 5.9%

**Table 1.** Summary of habitat diversity and stability, relative octopi abundance, and number of mollusk species associated with dens at each of three study sites. \*Habitat differs between sites and important components are ranked in order of dominance.

<b>Table 2. Bivalve Summary</b>		Page Coan	Mariner's Point		Mariner's Basin		Ventura Cove		
Species Coan et al., 2000	Total		% of total	Total	% of total	Total	% of total	Sum	
<i>Americardia biangulata</i> (Brod. & Sowerby 1829)	359	1	0.07	4	0.39	2	0.36	7	
<i>Anadara multistriata</i> (Sowerby, 1833)	134			1	0.10	4	0.72	5	
<i>Argopecten ventricosus</i> (Carpenter, 1864)	235			10	0.98	97	17.35	107	
<i>Chione californiensis</i> (Broderip, 1835)	369			5	0.20	1	0.18	6	
<i>Chione undatella</i> (Sowerby, 1835)	369	26	1.71	103	10.13	28	5.01	157	
<i>Clinocardium nuttalli</i> (Conrad, 1837)	351			1	0.10			1	
<i>Crassadoma gigantea</i> (Gray, 1825)	238	3	0.20					3	
<i>Cryptomya californica</i> (Conrad, 1837)	474	29	1.90	2	0.20			31	
<i>Cumingia californica</i> (Conrad, 1837)	437	6	0.39	5	0.48			11	
<i>Cyathodonta pedroana</i> Dall, 1915	536	3	0.20	1	0.10	2	0.36	6	
<i>Diplodonta orbella</i> (Gould, 1851)	270	19	1.25	2	0.20			21	
<i>Donax californicus</i> (Conrad, 1837)	422			1	0.10			1	
<i>Donax gouldi</i> Dall, 1921	423	3	0.20	1	0.10			4	
<i>Gari californica</i> (Conrad, 1849)	426	104	6.83	37	3.64	1	0.18	142	
<i>Heterodonax pacificus</i> (Conrad, 1837)	428	1	0.07					1	
<i>Laevicardium substriatum</i> (Conrad, 1837)	360	48	3.15	118	11.60	96	17.17	262	
<i>Leporimetis obesa</i> (Deshayes, 1855)	420	17	1.12	7	0.69			24	
<i>Limaria hemphilli</i> Hertlein & Strong, 1946	205	18	1.18	6	0.59	1	0.18	24	
<i>Lucinisa nuttalli</i> (Conrad, 1837)	263			1	0.10			1	
<i>Macoma nasuta</i> (Conrad, 1837)	420	11	0.72	12	1.18	2	0.36	25	
<i>Macoma secta</i> (Conrad, 1837)	417	10	0.66	4	0.39			14	
<i>Mactrotoma californica</i> (Conrad, 1837)	457	42	2.76	15	1.47	5	0.89	62	
<i>Mactrotoma nasuta</i> (Gould, 1851)	456	2	0.13					2	
<i>Mactromeris hemphillii</i> (Dall, 1894)	454	3	0.20					3	
<i>Musculista senhousia</i> (Ben. in Cantor 1842)	167	14	0.92	6	0.59	3	0.54	23	
<i>Nuttallia nuttallii</i> (Conrad, 1837)	429	2	0.13			4	0.72	6	
<i>Periploma planiusculum</i> (Sowerby, 1834)	540	2	0.13	1	0.10			3	
<i>Pitar newcombianus</i> (Gabb, 1865)	380	1	0.07					1	
<i>Protothaca laciniata</i> (Carpenter, 1864)	374	38	2.50	45	4.42	1	0.18	84	
<i>Protothaca staminea</i> (Conrad, 1837)	374	8	0.53	11	1.08	3	0.54	22	
<i>Saxidomus nuttalli</i> (Conrad, 1837)	386	154	10.11	47	4.62	6	1.07	207	
<i>Semele decisa</i> (Conrad, 1837)	432	52	3.42	24	2.36			76	
<i>Solen rostriformis</i> Dunker, 1867	444	3	0.20	2	0.20			5	
<i>Tagelus californianus</i> (Conrad, 1837)	441	25	1.64	34	3.34	15	2.68	74	
<i>Tagelus subteres</i> (Conrad, 1837)	442	807	52.99	475	46.71	275	49.19	1557	
<i>Trachycardium quadrangularium</i> (Conrad, 1837)	362	54	3.55	29	2.85	12	2.15	95	
<i>Tresus nuttallii</i> (Conrad, 1837)	463	16	1.05	3	0.29			19	
<i>Venerupis philippinarum</i> (Adams & Reeve, 1850)	387	1	0.07	7	0.69	1	0.18	9	
Total		1,523	100%	1,020	100%	559	100%	3102	

**Table 2.** Summary of bivalves recovered from debris fields in three distinctly different habitats.

<b>Table 3. Gastropod Summary</b>	<b>Mariner's Point</b>		<b>Mariner's Basin</b>		<b>Ventura Cove</b>	
	Total	% of total	Total	% of total	Total	% of total
Species Berschauer & Clark, 2019						
<i>Bulla gouldiana</i> Pilsbry, 1893	90	21.0	32	51.6	31	81.6
<i>Californiconus californicus</i> Reeves, 1844	13	3.0	2	3.2	3	7.9
<i>Callianax biplicata</i> (Sowerby, 1825)	150	35.0	3	4.8	2	5.3
<i>Haliotis fulgens</i> Philippi, 1845	2	0.5				
<i>Kelletia kelletii</i> (Forbes, 1852)	4	0.9				
<i>Maxwellia gemma</i> (Sowerby, 1879)	3	0.7				
<i>Megathura crenulata</i> (Sowerby, 1825)	15	3.5				
<i>Megastraea undosa</i> (Wood, 1829)	50	11.7	10	16.1		
<i>Nassarius fossatus</i> (Gould, 1849)	1	0.2			1	1.4
<i>Neobernaya spadicea</i> (Swainson, 1832)	1	0.2				
<i>Neverita alata</i> (Pilsbry, 1929)	2	0.5				
<i>Neverita lewisii</i> (Gould, 1847)	1	0.2				
<i>Neverita reclusiana</i> (Deshayes, 1839)	9	2.1	2	3.2		
<i>Norrisia norrisi</i> (Sowerby, 1838)	12	2.8	4	6.5	1	2.6
<i>Pteropurpura festiva</i> (Hinds, 1844)	4	0.9				
<i>Roperia pouloni</i> (Carpenter, 1864)	3	0.7				
<i>Sinum scopulosum</i> (Conrad, 1849)	3	0.7				
<i>Tegula aureotincta</i> (Forbes, 1852)	8	1.9	1	1.6		
<i>Tegula eiseni</i> Jordan, 1936	52	12.1	8	12.9		
<i>Tegula funebralis</i> (A. Adams, 1855)	2	0.5				
<i>Tegula regina</i> (Stearns, 1892)	1	0.2				
<i>Trivia solandri</i> (Sowerby, 1832)	2	0.5				
Gastropod total	428	100%	62	100%	38	100%

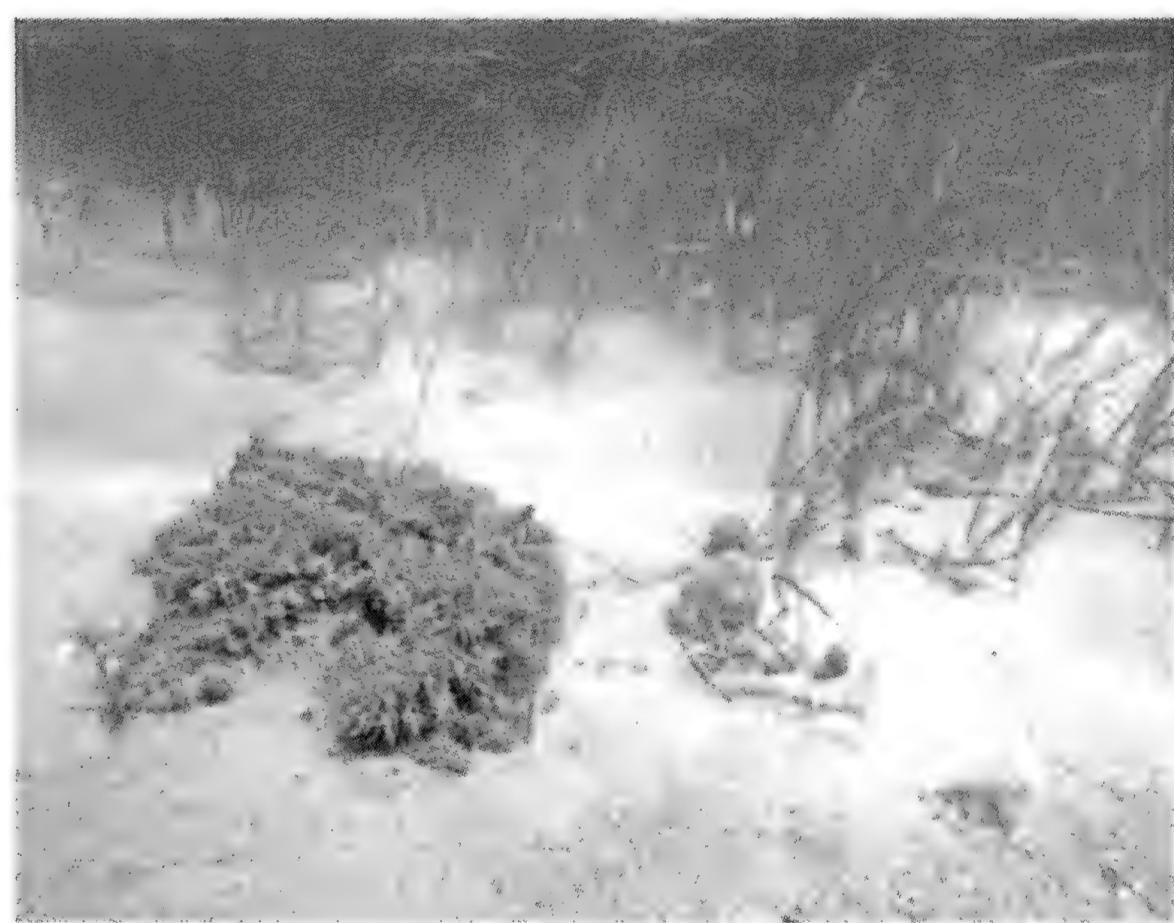
**Table 3.** Summary of gastropods recovered from debris fields in three distinctly different habitats.



**Fig. 2.** Location of study sites in Mission Bay, (1) Mariner's Point, (2) Mariner's Basin, (3) Ventura Cove.



**Fig. 3.** Mariner's Point UW habitat. Location 1.



**Fig. 4.** Mariner's Basin UW habitat. Location 2.



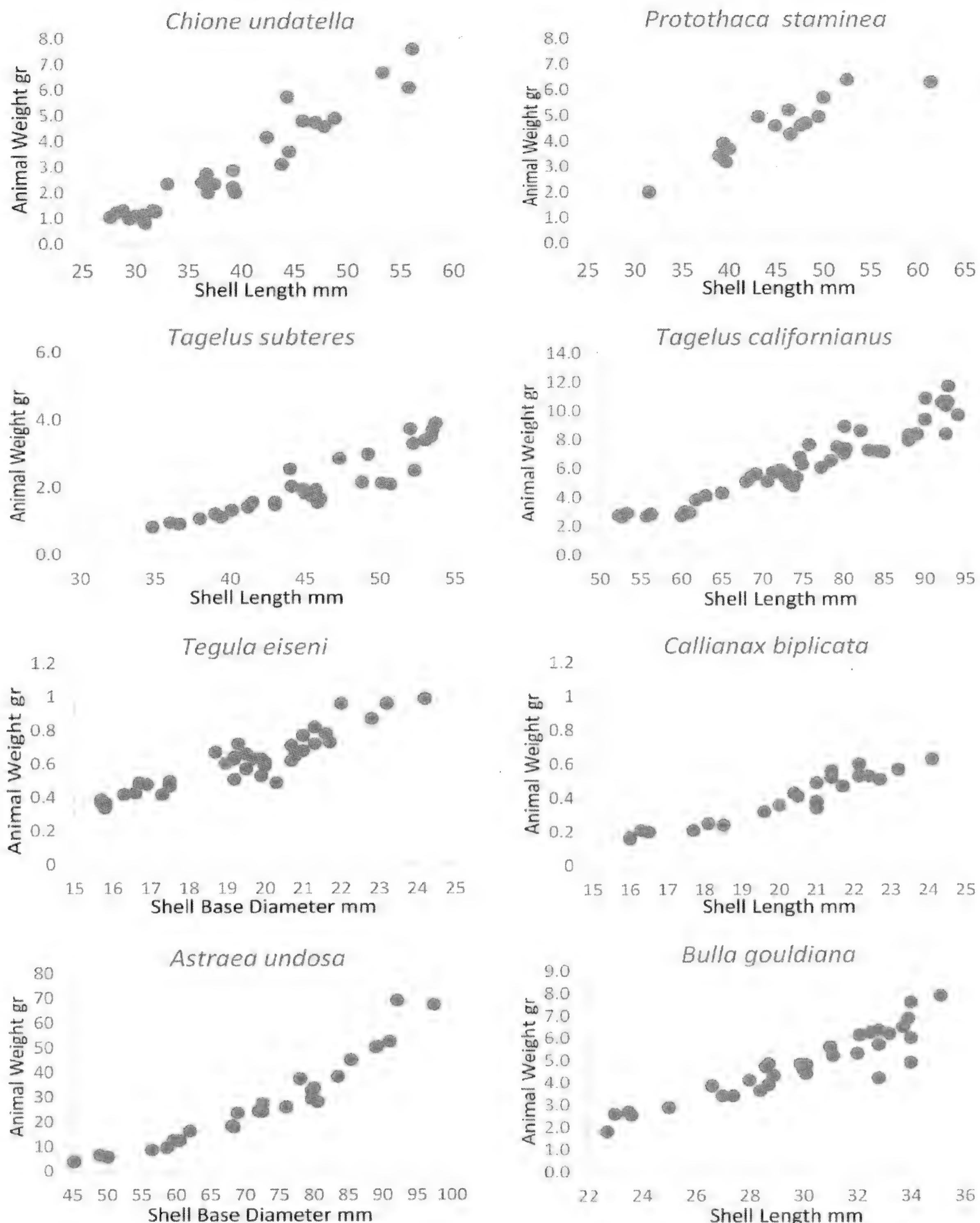
**Fig. 5.** Ventura Cove UW habitat. Location 3.



**Fig. 6.** *O. bimaculoides* at entry of sand/eel grass den. Ventura Cove.



**Fig. 7.** *Anadara multicostata* as mobile den. *Argopecten ventricosus* as shield. Ventura Cove.



**Figure 8.** Wet-weigh biomass vs. shell size of eight prey species commonly consumed by *Octopus bimaculoides* at Mariner's Point, Mission Bay. The red dot represents the average size of the prey species found in the debris fields.

## New Fossil Scaphelline Voluts from the Pliocene of Southern Florida

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**ABSTRACT** Three new scaphelline volutes, belonging to the genera *Scaphella* and *Volutifusus*, are described from Pliocene formations in southern Florida. The new taxa include *Scaphella kendrae* n. sp. from the Sarasota Member, Murdock Formation (Zanclean Age), *Volutifusus dougsheltoni* n. sp. from the Buckingham Member, Tamiami Formation (early Piacenzian Age), and *Volutifusus kissimmeensis* n. sp. from the Fruitville Member (Unit 2 Kissimmee facies equivalent), Tamiami Formation (late Piacenzian Age).

**KEY WORDS** Volutidae, Scaphellinae, *Scaphella*, *Volutifusus*, Florida, Sarasota, Kissimmee River, Pliocene Epoch, Zanclean Age, Piacenzian Age, Murdock Formation, Tamiami Formation, *Scaphella kendrae*, *Volutifusus dougsheltoni*, *Volutifusus kissimmeensis*

### INTRODUCTION

The scaphelline volutid genera *Scaphella* Swainson, 1832 and *Volutifusus* Conrad, 1863 are commonly-encountered taxa in the Pliocene and Pleistocene fossil beds of southern Florida. Recent taxonomic surveys of the fossil malacofaunas of southern Florida have shown that fifteen species of *Scaphella* and six species of *Volutifusus* were known from the fossil record, with the bulk of the species having been found in the Piacenzian Pliocene Tamiami Formation, the Gelasian Pleistocene Caloosahatchee Formation, and the Chibanian Pleistocene Bermont Formation (Petuch, 1994, 2004; Petuch and Roberts, 2007; Petuch and Berschauer, 2021). All of these scaphelline taxa are stratigraphically and chronologically highly-restricted and they have proven to be invaluable tools, as guide fossils, for determining the boundaries between the members and formations in the regional geology.

While in the process of completing a new comprehensive book on the geology, paleontology, and paleoceanography of the Everglades region, we discovered that three Floridian scaphelline volutes remained undescribed and had not been recognized or illustrated in any previous paleontological surveys. Since these three volutes, a new species of *Scaphella* and two new species of *Volutifusus*, were found to be important, stratigraphically-restricted index fossils for the Pliocene beds, we have decided that they need names and will be included in our upcoming geology book. These include the oldest-known species of *Scaphella* from the Sarasota Member of the Murdock Formation (Zanclean Pliocene), a new elongated *Volutifusus* from the Buckingham Member of the Tamiami Formation (early Piacenzian Pliocene), and a new heavily-sculptured *Volutifusus* from the Fruitville Member of the Tamiami Formation (late Piacenzian Pliocene). The holotypes of the three new species are deposited in the Molluscan Paleontology Collections of the Los

Angeles County Museum of Natural History, Los Angeles, California and bear LACMIP numbers. These three newly-discovered volutes are described in the following sections.

## SYSTEMATICS

Class	:	Gastropoda
Subclass	:	Sorbeoconcha
Order	:	Prosobranchia
Infraorder	:	Neogastropoda
Superfamily	:	Vulitoidea
Family	:	Volutidae
Subfamily	:	Scaphellinae

Genus *Scaphella* Swainson, 1832

*Scaphella kendrae* Petuch and Berschauer,  
new species  
(Figure 1A, B)

**Description.** Shell small for genus, fusiform, biconic, with elevated spire whorls; shoulder angled, with broadly rounded edge, placed at demarcation line between anterior and posterior halves of body whorl; subsutural areas of spire whorls and shoulder distinctly sloping; siphonal canal proportionally very short, nearly obsolete; aperture moderately wide and flaring; columella with 4 large plicae, with plicae grouped closest to anterior end of shell; posterior half of columella without folds or ornamentation; early whorls smooth, with only faint and poorly-developed small longitudinal ribs on first postnuclear whorl; protoconch proportionally large, rounded and dome-like.

**Type Material.** HOLOTYPE - Length 42.0 mm, width 18.8 mm, from Unit 11A in Quality Aggregates Pit #6, Sarasota, Florida. LACMIP 43080.1, LACMIP Type 14891.

**Type Locality and Stratigraphic Range.** The holotype was collected in the upper section of the basal bed (Unit 11 of Petuch, 1982; Petuch and Roberts, 2007; Petuch and Berschauer,

2021) in Quality Aggregates Pit #6 at Sarasota, Sarasota County, Florida. Here, the new species was found to be confined to a single thin indurated sandstone layer on the upper surface of Unit 11 (referred to as "Unit 11A") of the Sarasota Member, Murdock Formation, Zanclean Age of the early Pliocene.

**Etymology.** Named for Kendra Berentsen of New York City, a gifted opera singer, an avid amateur naturalist, and the daughter-in-law of the senior author.

**Discussion.** Since the thin sandstone layer on the upper surface of the Sarasota Member of the Murdock Formation has only been seen in one Sarasota quarry (Quality Aggregates Pit #6), only a single specimen of this new *Scaphella* species has ever been collected. The thin layer, referred to as "Unit 11A", was only exposed within a small area and only a few well-preserved gastropods and bivalves were collected. Besides the unique holotype of *Scaphella kendrae*, other Unit 11A mollusks included a small undescribed *Tropochasca* species (Echinofulguridae), an undescribed *Akleistostoma* species (ancestral to the early Piacenzian *A. pilsbryi*, Cypraeidae), an undescribed *Pterorhytis* species (Muricidae), and the pholadomyid bivalve *Margaritaria abrupta*. As the entire underlying Sarasota Member (Murdock Formation) is heavily leached by groundwater from early Pliocene deltas, only calcitic fossils are preserved and are represented by large numbers of barnacles such as *Chesaconcavus*, muricid gastropods such as *Ecphora* and *Planecphora*, and pectinid bivalves such as *Chesapecten*, *Carolinapecten*, and *Cristinapecten* (Petuch, 2004; Petuch and Roberts, 2007; Petuch and Berschauer, 2021). The new molluscan fauna found in Unit 11A, which includes the new volute, is the only-known unit within the Murdock Formation that contains well-preserved aragonitic fossils. The

well-preserved gastropods of this thin layer demonstrates that the ancestral lineages of the remarkable molluscan fauna of the overlying Buckingham Member of the Tamiami Formation were already well-established by the late Zanclean Age.

Of the known Florida *Scaphella* species, the new Murdock Formation volute is most similar to *Scaphella martinshugari* Petuch, 1994 (Figure 1C, D) from the overlying Piacenzian-aged Buckingham Member of the Tamiami Formation, but differs in being a smaller, more slender and less-inflated shell with a much higher and more protracted spire, and in having smoother, less-sculptured early whorls. The distinct shoulder angle, biconic appearance, and short siphonal canal of *Scaphella kendrae* also set it aside from all other known congeners. In having these last three shell characters, along with its small size, the new Unit 11A volute also resembles *Atraktus florea* (Gardner, 1947: 637-638, plate 52, figure 31) from the Shoal River Formation of the Florida Panhandle (Serravallian Age of the Middle Miocene), but differs in having a higher and more protracted spire and in being a less-sculptured shell that lacks the fine longitudinal ribbing seen on the body whorl and spire of *A. florea*. Based on its stratigraphic position within the Zanclean Pliocene beds of southern Florida and the southeastern United States, *Scaphella kendrae* appears to be the oldest-known true *Scaphella* and is ancestral to the taxa that are found in the subsequent Piacenzian Pliocene and Pleistocene formations and members. These descendant taxa are listed here in the following table.

**List of Named *Scaphella* Species Known from the Pliocene and Pleistocene of the Florida.** (All the described species of *Scaphella* are arranged here stratigraphically and geochronologically; these are illustrated in

Petuch, 1994, 2004; Petuch and Berschauer, 2021).

#### Zanclean Age, Pliocene

*Scaphella kendrae* Petuch and Berschauer, n.sp. (Unit 11A, Sarasota Member, Murdock Formation.). (Oldest-known true *Scaphella* and the morphological transition form between the Middle and Late Miocene genus *Atraktus* and Pliocene-Holocene genus *Scaphella* (*sensu stricto*)).

#### Piacenzian Age, Pliocene

*Scaphella martinshugari* Petuch, 1994 (Buckingham Member, Tamiami Formation)

*Scaphella ashleyae* Petuch, 1994 (Buckingham Member, Tamiami Formation)

*Scaphella trenholmii* (Tuomey and Holmes, 1856) (Pinecrest Member, Tamiami Formation; also known from the Duplin Formation of the Carolinas)

*Scaphella mansfieldi* Petuch, 1994 (Pinecrest Member, Tamiami Formation; also known from the Duplin Formation of the Carolinas)

*Scaphella petiti* Petuch, 1994 (Unit 4 Fruitville Member, Tamiami Formation)

*Scaphella gravesae* Petuch, 1994 (Unit 3 Fruitville Member, Tamiami Formation)

*Scaphella maureenae* Petuch, 1994 (Unit 3 Fruitville Member, Tamiami Formation)

*Scaphella danielleae* Petuch, 1994 (Unit 2, Fruitville Member, Tamiami Formation)

*Scaphella brennmortoni* Olsson and Petit, 1964 (Unit 2, Fruitville Member, Tamiami Formation; also known from the upper beds of the Waccamaw Formation of the Carolinas)

#### Gelasian Age, Pleistocene

*Scaphella floridana* Heilprin, 1886 (Fort Denaud Member, Caloosahatchee Formation)

*Scaphella tomscotti* Petuch, 1994 (Ayers Landing Member, Caloosahatchee Formation)

*Scaphella griffini* Petuch, 1994 (Ayers Landing Member, Caloosahatchee Formation)

*Scaphella oleiniki* Petuch, 1994 (Ayers Landing Member, Caloosahatchee Formation)

**Chibanian Age, Pleistocene**

*Scaphella capelettii* Petuch, 1994 (Holey Land Member, Bermont Formation)

*Scaphella seminole* Petuch, 1994 (Holey Land Member, Bermont Formation)

Superfamily : Volutoidea  
 Family : Volutidae  
 Subfamily : Scaphellinae  
 Genus *Volutifusus* Conrad, 1863

*Volutifusus dougsheltoni* Petuch and Berschauer,  
 new species  
 (Figure 1E, F)

**Description.** Shell of average size for genus, extremely elongated and fusiform, with narrow, cylindrical body whorl and very high, protracted spire; shoulders of spire whorls ornamented with 10-12 large, prominent elongated, evenly-spaced elongated knobs that are arranged longitudinally; spire whorls with 10-12 elongated knobs per whorl; elongated knobs also extend onto first half of body whorl, along apertural side, giving shell pleated, lyriaform appearance; dorsum of body whorl smooth and lacking elongated knobs; aperture elongated and narrow; columella with 2 large widely-spaced plicae; protoconch bulbous, rounded, composed of 2 whorls.

**Type Material.** HOLOTYPE - Length 118.2 mm, width 37.1 mm, from the Buckingham Member, Tamiami Formation at Sarasota, LACMIP 43081.1, LACMIP Type 14892; OTHER MATERIAL EXAMINED - 2 specimens, lengths 121 mm and 116 mm, from the same locality and stratigraphic unit as the holotype, in the research collection of the senior author; length 71.0 mm, from the same locality and stratigraphic unit as the holotype, in the research collection of Douglas Shelton, Mobile, Alabama; length 74 mm, from the lower bed of the Jackson Bluff Formation (the "Ecphora

Zone") at Alum Bluff, Liberty County, Florida, in the research collection of the senior author.

**Type Locality and Stratigraphic Range.** The holotype was collected in the basal bed of Unit 10 (Petuch, 1982; Petuch and Roberts, 2007; Petuch and Berschauer, 2021) in Quality Aggregates Pit #6, Sarasota, Sarasota County, Florida. Here, the new species was found to be restricted to the Buckingham Member of the Tamiami Formation, early Piacenzian Age of the late Pliocene. Specimens of this new species have also been collected in the contemporaneous lower beds of the Jackson Bluff Formation at Alum Bluff on the Apalachicola River.

**Etymology.** Named for Douglas Shelton of Mobile, Alabama, well-known local expert on the American Volutidae and who has made many important contributions to our knowledge of the Scaphellinae.

**Discussion.** Within the Buckingham Member beds at Sarasota, *Volutifusus dougsheltoni* is a rarely-seen species and occurs together with the much more common *Volutifusus emmonsi* Petuch, 1994 (Figure 2D). Although similar in appearance, the new species differs from the more abundant *V. emmonsi* in being a much larger shell (averaging 125 mm as opposed to 80 mm for *V. emmonsi*), in having a much narrower and more elongated shell with a distinctly stretched-out appearance, and in having proportionally-larger, better-developed, and more prominent knobs on the spire whorls. On *V. dougsheltoni*, the spire whorl knobs continue onto the body whorl as elongated plicae, at least as far as half way around the shell. On *V. emmonsi*, the spire whorl knobs are less-developed and end along the penultimate whorl, never extending onto the aperture side of the body whorl.

*Volutifusus kissimmeensis* Petuch and Berschauer, new species  
(Figure 2A, B, C)

**Description.** Shell of average size for genus, elongated and cylindrical, with proportionally low spire whorls; body whorl at least two-thirds of overall shell length; shoulder sloping, distinctly angled, sharply-edged on earlier whorls; angled shoulder and spire whorls ornamented with 14-15 prominent, rib-like, evenly-spaced elongated knobs, which extend onto first 3 whorls; elongated knobs diminish in size and disappear on body whorl of fully adult specimens; aperture very long and narrow; columella slightly curved, ornamented with 2 large, prominent plicae; protoconch proportionally large, rounded, dome-like, composed of 2 whorls.

**Type Material.** HOLOTYPE - Length 78.5 mm, width 30.0 mm, Fruitville Member Unit 2 beds in the Rucks Pit, Fort Drum, Okeechobee County, Florida (broken subadult specimen, LACMIP 43082.1, LACMIP Type 14893); OTHER MATERIAL EXAMINED - length 105 mm (fully adult specimen), from the same locality and stratigraphic unit as the holotype, in the research collection of the senior author.

**Type Locality and Stratigraphic Range.** The holotype was collected in the uppermost section of the lowest beds in the Rucks Pit, Fort Drum, Okeechobee County, Florida, which represent the Kissimmee Valley facies of the Fruitville Unit 2 equivalent beds of the Tamiami Formation, late Piacenzian Age of the late Pliocene.

**Etymology.** Named for the Kissimmee River of southern Florida, which now occupies a buried lagoon-like bay, the Kissimmee Embayment of the Pliocene Okeechobean Sea. This ancient

embayment contained the endemic ecosystem that was home to the new species.

**Discussion.** The new species, *Volutifusus kissimmeensis*, is presently known from only two specimens; a broken fragmentary holotype with well-preserved sculpture and knobs on the early whorls (Figure 2 A, B) and a beach-worn but fully adult specimen with an intact body whorl (Figure 2C). Together, the two specimens allow for an accurate reconstruction of the appearance of a perfect adult shell. The broken specimen was chosen to be the holotype because of the good preservation of the diagnostic sculpture on the spire whorls; this was essentially worn off the more complete specimen. Of the known Florida Pliocene *Volutifusus* species, *V. kissimmeensis* most closely resembles *V. obtusus* (Emmons, 1858) (Figure 2F) from the older Pinecrest Member of the Tamiami Formation, but differs in being a smaller, much more slender shell with noticeably lower spire whorls and in having much stronger, more numerous knobs on the spire whorls. In *V. obtusus*, the knobs on the spire extend only onto the first two postnuclear whorls, while on *V. kissimmeensis* they extend to the third whorl and around to the edge of the body whorl. The new species is also similar to *V. auroraensis* Petuch, 1994 (Figure 2E), which occurs along with *V. kissimmeensis* in the Unit 2 equivalent beds, but differs in having a much more flattened spire with stronger and more numerous rounded spire knobs and in having far less indented sutures.

The two new *Volutifusus* species are part of a large complex of Eastern American species that ranges from the early Miocene (Langhian Age) to the Early Pleistocene (Gelasian Age). Although at least seven *Volutifusus* species are known from the Miocene of Maryland and Virginia (Petuch, 2004), an equal number of species also has been reported from the Pliocene

of Florida and these are listed here by geochronology. A single Early Pleistocene species is known from the Virginia, the Carolinas, and Florida and the genus disappears from the fossil record at the end of Gelasian time. Three species of living *Volutifusus* are also known from deep water areas off the southeastern United States, Bahamas, and Cuba, and include *V. piraticus* (Clench and Aguayo, 1940), *V. torrei* (Pilsbry, 1937), and *V. aguayoi* (Clench, 1940). After disappearing from shallow water areas during the Middle and Late Pleistocene, the genus appears to have found a refugium in these protected deep water environments. The Pliocene and Pleistocene Floridian *Volutifusus* species are listed on the following table.

#### List of Named *Volutifusus* Species Known from the Pliocene and Pleistocene of Florida.

(All the described *Volutifusus* species are arranged here stratigraphically and geochronologically; these are illustrated in Petuch, 1994, 2004; Petuch and Berschauer, 2021).

##### Piacenzian Age, Pliocene.

*Volutifusus emmonsi* Petuch, 1994 (Buckingham Member, Tamiami Formation; also known from the lower beds of the Jackson Bluff Formation at Alum Bluff and the Yorktown Formation of Virginia and North Carolina)

*Volutifusus dougsheltoni* Petuch and Berschauer, n. sp. (Buckingham Member, Tamiami Formation; also known from the lower beds of the Jackson Bluff Formation at Alum Bluff)

*Volutifusus spengleri* Petuch, 1994 (Pinecrest Member, Tamiami Formation; also known from the Yorktown Formation of Virginia and Duplin Formation of the Carolinas)

*Volutifusus obtusus* (Emmons, 1858) (Pinecrest Member, Tamiami Formation; also known from the Yorktown Formation of Virginia and Duplin Formation of the Carolinas)

*Volutifusus kissimmeensis* Petuch and Berschauer, n.sp. (Unit 2 Fruitville Member, Tamiami Formation.)

*Volutifusus auroraensis* Petuch, 1994 (Unit 2 Fruitville Member, Tamiami Formation; also found in the Chowan River Formation of Virginia and North Carolina)

*Volutifusus typus* Conrad, 1866 (Unit 2 Fruitville Member, Tamiami Formation; also found in the Chowan River Formation of Virginia and North Carolina)

##### Gelasian Age, Pleistocene.

*Volutifusus halscotti* Petuch, 1994 (Rucks Pit Member, Nashua Formation; also found in the Waccamaw Formation of the Carolinas)

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**Figure 1. *Scaphella* and *Volutifusus* Species from the Pliocene of Southern Florida.**

**A, B=** *Scaphella kendrae* Petuch and Berschauer, new species, holotype, length 42.0 mm, from the uppermost bed of the Sarasota Member, Murdock Formation, Unit 11A in Quality Aggregates Pit #6, Sarasota, Sarasota County, Florida, Zanclean Age of the early Pliocene, LACMIP 14891; **C, D=** *Scaphella martinshugari* Petuch, 1994, length 59.0 mm, from Unit 10 in Quality Aggregates Pit #6, Sarasota, Sarasota County, Florida, Buckingham Member, Tamiami Formation, early Piacenzian Age of the late Pliocene (for comparison with *S. kendrae*); **E, F=** *Volutifusus dougsheltoni* Petuch and Berschauer, new species, holotype, length 118.2 mm, from Unit 10 in Quality Aggregates Pit #6, Sarasota, Sarasota County, Florida, Buckingham Member, Tamiami Formation, early Piacenzian Age of the late Pliocene, LACMIP 14892.



**Figure 2.** *Volutifusus* Species from the Pliocene of Southern Florida.

**A, B**= *Volutifusus kissimmeensis* Petuch and Berschauer, new species, holotype, length 78.5 mm, from the upper section of the lower beds in the Rucks Pit, Fort Drum, Okeechobee County, Florida, Unit 2 Fruitville Member equivalent, Tamiami Formation, late Piacenzian Age of the late Pliocene, LACMIP 14893; **C**= *Volutifusus kissimmeensis* Petuch and Berschauer, new species, length 105 mm, from the upper section of the lower beds in the Rucks Pit, Fort Drum, Okeechobee County, Florida, Unit 2 Fruitville Member equivalent, Tamiami Formation, late Piacenzian Age of the late Pliocene (beach-worn fully adult specimen); **D**= *Volutifusus emmonsii* Petuch, 1994, length 84.2 mm, from Unit 10 in Quality Aggregates Pit #6, Sarasota, Sarasota County, Florida, from Unit 10 in Quality Aggregates Pit #6, Sarasota, Sarasota County, Florida, Buckingham Member, Tamiami Formation, early Piacenzian Age of the late Pliocene; **E**= *Volutifusus auroraensis* Petuch, 1994, length 110 mm, from the old Lee Creek Phosphate Mine, Aurora, Beaufort County, North Carolina, Chowan River Formation, late Piacenzian Age of the late Pliocene (also found in Unit 2 equivalent Fruitville Member beds of the Tamiami Formation in southern Florida; for comparison with *V. kissimmeensis*); **F**= *Volutifusus obtusus* (Emmons, 1858), length 130 mm, from the lowest beds exposed in the Rucks Pit, Fort Drum, Okeechobee County, Florida, Pinecrest Member equivalent, Tamiami Formation, late Piacenzian Age of the late Pliocene (for comparison with *V. kissimmeensis*).

## Description of two new *Jaspidiconus* species from Bahia State, Brazil

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**ABSTRACT** Two new *Jaspidiconus* species from Bahia State, Brazil are described here and compared to other similar taxa from the Brazilian Molluscan Province. A new taxon, *Jaspidiconus vanini* n. sp., is described from Bahia and Espírito Santo States, Brazil and compared to the similar *Jaspidiconus simonei* Petuch & Myers, 2014 and *Jaspidiconus poremskii* Petuch & Myers, 2014. Another new taxon, *Jaspidiconus tinharensis* n. sp., is described from Morro de São Paulo, Bahia State, Brazil and is compared to the similar *Jaspidiconus simonei* Petuch & Myers, 2014, *Jaspidiconus marinae* Petuch & Myers, 2014, *Jaspidiconus ogum* Petuch & Myers, 2014, and *Jaspidiconus icapui* Petuch & Berschauer, 2018.

**KEY WORDS** Conidae, Brazilian Molluscan Province, Bahia State, *Jaspidiconus*, *Jaspidiconus vanini*, *Jaspidiconus tinharensis*

### INTRODUCTION

This paper is dedicated to both our friend and mentor Dr. Sergio Vanin, entomologist at Institute of Biology of University São Paulo USP (see Figure 1), who died on 21 October 2020, and to his wife Dr. Ana Maria Pires-Vanin, oceanographer at Oceanic Institute from USP. Over the years, Dr. Sergio Vanin gave many excellent presentations at the meetings of the Brazilian Shell Club “Conquiliologista do Brasil” with important information on taxonomy and systematic of molluscs. We follow the lead of our mentor Dr. Vanin in describing only new species, which we trust to be distinguishable from existing taxa.

Taxonomically we follow Petuch (2004), Tucker & Tenorio (2013), and Monnier, *et al.* (2018) and use the genus *Jaspidiconus* Petuch, 2004 rather than *Conasprella* Thiele, 1929, as

proposed by Puillandre, *et al.* (2015). This approach is more logical as biogeographically and evolutionarily *Conasprella* species evolved in the Indo Pacific, and *Jaspidiconus* is a paleontologically recent genus, which evolved from *Ximeniconus* in the Carolinean and Caribbean Provinces (Monnier, *et al.*, 2018).



Figure 1. Dr. Sergio Vanin.



Figure 2. Corumbau Beach,

It is important to note that the Conidae Fleming, 1822 is a very diverse family, and that with exploration and discovery the number of Brazilian conid species has increased every year. One explanation for this fact is that in the early stages of development most of the *Jaspidiconus* Petuch, 2004 species have lechithotrophic benthic development, (*i.e.* they are direct developers with no planktonic larval stage and therefore have a limited dispersal abilities (Petuch & Myers, 2014; Berschauer, 2015)). Accordingly, most taxa in the genus have quite restricted habitats and there is significant endemism. The Abrolhos Platform and reef has only recently begun to be studied and its molluscan biodiversity still virtually unknown. However, recent preliminary studies have indicated that the platform has unusually high levels of both species-richness and endemism, especially in the family Conidae (Petuch, 2013; Petuch and Berschauer, 2018; Petuch, Coltro & Berschauer, 2020). Based on our field observations, we find the territory of some species appears to be more extended than what was originally understood (*Jaspidiconus ogum* Petuch & Myers, 2014 and *J. marinae* Petuch & Myers, 2014 for instance), whereas other species still seem to be present in a very restricted locality - such as *J. itapua* Petuch & Berschauer, 2016, which is only known from Itapuã beach.

The new species described herein are: *Jaspidiconus vanini* n. sp. from Corumbau (Bahia) (Figure 2) to Guarapari (Espírito Santo), which is distinct from *J. simonei* Petuch & Myers, 2014 and *J. poremskii* Petuch & Myers, 2014; and, *Jaspidiconus tinharensis* n. sp. from Morro de São Paulo and Barra Grande, which is distinct from *J. marinae* Petuch & Myers, 2014, *J. simonei* Petuch & Myers, 2014, *J. ogum* Petuch & Myers, 2014, and *J. icapui* Petuch & Berschauer, 2018. Both of these two new cone

species are found in Bahia State, northeast Brazil.

## MATERIALS AND METHODS

We describe the shell morphology using the terminology established in Röckel, *et al.* (1995) and modified in Monnier, *et al.* (2018). Adult specimens were measured using digital calipers; measurements were rounded to the millimeter except for holotypes. The holotypes will be deposited at the MZSP with the following type numbers: *Jaspidiconus vanini* MZSP152459, and *Jaspidiconus tinharensis* MZSP152461.

## ABBREVIATIONS

MZSP: Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil

MOEGR : Museu Oceanográfico Eliezer Rios de Carvalho, Rio Grande RS, Brazil

UNICAMP, Campinas, São Paulo State, Brazil

OC: Olivier Crabs reference collection, Salvador, Bahia, Brazil

GO: Geraldo Semer Pomponet Oliveira, reference collection, Salvador, Bahia, Brazil

LA: Laudelino Passos de Almeida, reference collection, Salvador, Bahia, Brazil

GQ: Gregorio Pereira de Queiroz, reference collection, São Paulo, São Paulo State, Brazil

## SYSTEMATICS

Class	:	Gastropoda
Subclass	:	Sorbeoconcha
Order	:	Prosobranchia
Infraorder	:	Neogastropoda
Superfamily	:	Conoidea
Family	:	Conidae
Subfamily	:	Conilithinae
Genus	<i>Jaspidiconus</i>	Petuch, 2004

*Jaspidiconus vanini*, Crabos, Oliveira, Almeida, & Queiroz, new species  
(Plate 1, Figures A-I)

**Description.** Shell of medium size from 20 to 26 mm in length, rather slender (approximately half as broad as long), coloured from orange to brown, spire with a white zone on its inferior part, base colour pale orange or pale brown covered with darker patches, 16 to 20 beads visible on the body whorl, coloration alternates white and orange or brown, straight sides, smooth shoulder, orange or brown marks alternating with white, protoconch pale pink to white, aperture pale orange to pale brown.

**Type Material.** Holotype and 4 paratypes. The holotype is deposited in the Museu de Zoologia da Universidade de São Paulo, Brazil under the number MZSP152459, the paratypes are in private collections. Material examined: 5 specimens of *Jaspidiconus vanini* sp. nov. have been examined. The holotype measures 26.7 mm in length by 12.5 mm in width (Plate 1, Figures A, B). Paratype 1 measures 21 mm in length (Plate 1, Figures C, D, and protoconch view = I), paratype 2 measures 20 mm in length (Plate 1, Figures E, F), paratype 3 measures 26 mm in length (not illustrated), paratype 4 measures 19 mm in length and was collected in Trancoso, Bahia State, Brazil (Plate 1, Figures G, H). Paratypes 1 and 2 are in the private collection of Olivier Crabos; paratype 3 is in the collection of Geraldo Semer Pomponet Oliveira; paratype 4 is in the collection of Fabiano Ramos.

**Locality.** A live specimen of *Jaspidiconus vanini* was first found on a large region, from Morro de São Paulo on Tinhare Island South of Salvador to Guarapari, Espírito Santo. Paratype 2 was found alive at low tide in Corumbau (See Figure 2), the other specimens were dead collected. All specimens were collected between 0 and 1.5 meter deep. The holotype was found

at Guarapari region, Espírito Santo, at 1.5 m deep on sand. Paratype 1 from Corumbau BA, paratype 2 was found at Alcobaça, Bahia State, and paratype 3 was found at Morro de São Paulo, Bahia State. (Figure 3)

**Discussion.** Initially we had identified this species as *J. poremskii* due to the location where it was first found (as Corumbau is the type location of *J. poremskii*) and its orange colour, but the average size of *J. poremskii* is 15 mm whereas *J. vanini* varies from 20 to 26 mm, and does not have nodules on the shoulder, which are present on *J. poremskii* (Plate 1, Figures J, K). *J. vanini* also compares to *Jaspidiconus simonei*, but *J. simonei* is mostly dark brown to dark purple coloured and does not carry orange tones (Plate 2, Figures J, K). The background colour of *J. simonei* is white, grey or brown grey, whereas the background on *J. vanini* is pale orange.

**Etymology.** This species is dedicated to our friend and mentor Dr. Sergio Vanin, entomologist at Institute of Biology of University São Paulo USP, who died on 21 October 2020 and to his wife Dr. Ana Maria Pires-Vanin, oceanographer at Oceanic Institute from USP.



Figure 3. Morro de São Paulo Beach.

*Jaspidiconus tinharensis*, Crabos, Oliveira,  
Almeida, & Queiroz, new species  
(Plate 2, Figures A-F)

**Description.** Shell of medium size from 17 to 24 mm in length, rather slender (approximately half as broad as long), coloured dark brown with many thin black lines and small white patches, spire dark brown colour, base colour black covered with white patches, 19 to 23 beads visible on the body whorl, straight sides, shoulder smooth, orange or brown marks alternating with white, protoconch pale brown, aperture dark gray to dark brown.

**Type Material.** The holotype measures length 20.6 mm in length by 9.9 mm in width. The holotype is deposited in the Museu de Zoologia da Universidade de São Paulo, Brazil under the number MZSP152461, and is from Morro de São Paulo (Plate 2, Figures A, B, and protoconch view = F). Paratype 1 measures 20.9 mm in length and is at MNHN (Plate 2, Figures C, D); paratype 2 measures 20.7 mm in length and is at MOECR (Plate 2, Figure E); paratype 3 (not illustrated) measures 17.9 mm in length and is at UNICAMP; paratypes 4 through 8 (not illustrated) measure 21.4 mm, 22.7 mm, 22.9 mm, 23.0 mm and 23.6 mm in length and are housed in the research collection of Geraldo Semer Pomponet Oliveira, all from the same locality as the holotype. Paratype 9 measures 22.5 mm in length and is in the research collection of Laudelino Almeida, found in Barra Grande, Camamu Bay, Bahia State, Brazil.

**Locality.** Collected by Geraldo Semer Pomponet Oliveira in sand in tide pools at low tide, Morro de São Paulo, Tinhare Island, Bahia State, Brazil (See Figure 3). Also collected by Laudelino Almeida in Barra Grande, Camamu Bay, Bahia State, Brazil.

**Range.** The new species is known to range only along the coastlines from Tinhare Island to Camamu Bay, Bahia State, Brazil.

**Discussion.** *Jaspidiconus tinharensis* is darker than *J. marinae* (Plate 2, Figures G, H, and protoconch view = I), its spiral sutures are neater and deeper than *J. marinae*, and the superficial aspect is dull whereas the shell of *J. marinae* is porcellaneous, and its protoconch coloured in red or brown and is consistently darker than the protoconch of *J. marinae*. Further, *J. tinharensis* lives on a different island 80 kms south of Itaparica. *Jaspidiconus tinharensis* has a more slender body shape compared to *J. ogum*, a darker colour and does not have granules like *J. ogum* (Plate 2, Figure L). *Jaspidiconus tinharensis* is slim compared to *J. simonei*, smaller overall, has a taller spire and its body whorl is longer than *J. simonei* and is found at 800 kms distance from Guarapari (Espirito Santo) where *J. simonei* is found. Finally, the shell shape of *Jaspidiconus tinharensis* is substantially taller than *J. icapui*, has a slim shape and lives more than 1100 kms from Icapui (Ceara) where *J. icapui* is found.

**Etymology.** The taxon is named for Tinhare Island, where it was discovered. Tinhare Island is an important island for study of mollusks in the Bahia State, Brazil.

## CONCLUSIONS

There are still many undescribed Conidae from Brazil, the richest fauna being those from Bahia and Espirito Santo. Mauricio Andrade Lima has brought to our attention new species of cones from Pernambuco/Rio Grande do Norte/Ceara, which still need to be described. The limiting factor for the moment is that many different new species have been found with only one specimen, and very few specimens have been found alive to allow DNA tests that may be

desirable to further understand these new species. We miss our friend Sergio Vanin's support, advice, and friendship. In conclusion, in an Alexandre Dumas style (we call ourselves the 4 musketeers): "Un pour tous, tous pour un" which means One for all, all for one in French language.

## ACKNOWLEDGEMENTS

We thank the following: Dr. Sergio Vanin and Dr. Ana Maria Pires-Vanin, São Paulo, Brazil to whom this article is dedicated; Alfredo ("Nego") Bodart, Guarapari, Brazil from whom we purchased study material, Luiz Couto, Mar a Mar, Guarapari, Brazil, for his assistance with conid taxonomy; Dr. Edward J. Petuch, Florida Atlantic University and Dr. Eric Monnier, Paris, France, for their insights into the systematics of Brazilian Conidae; Flavio Dias Passos and Alan Heilan of Unicamp, who kindly photographed our study materia; Dr. Luiz Simone, Zoological Museums of the University of São Paulo who deposited the holotypes; and Bernardo Linhares, Salvador, Brazil, local expert on the molluscan fauna of Bahia State and who has been an inspiration to generations of Brazilian shell collectors.

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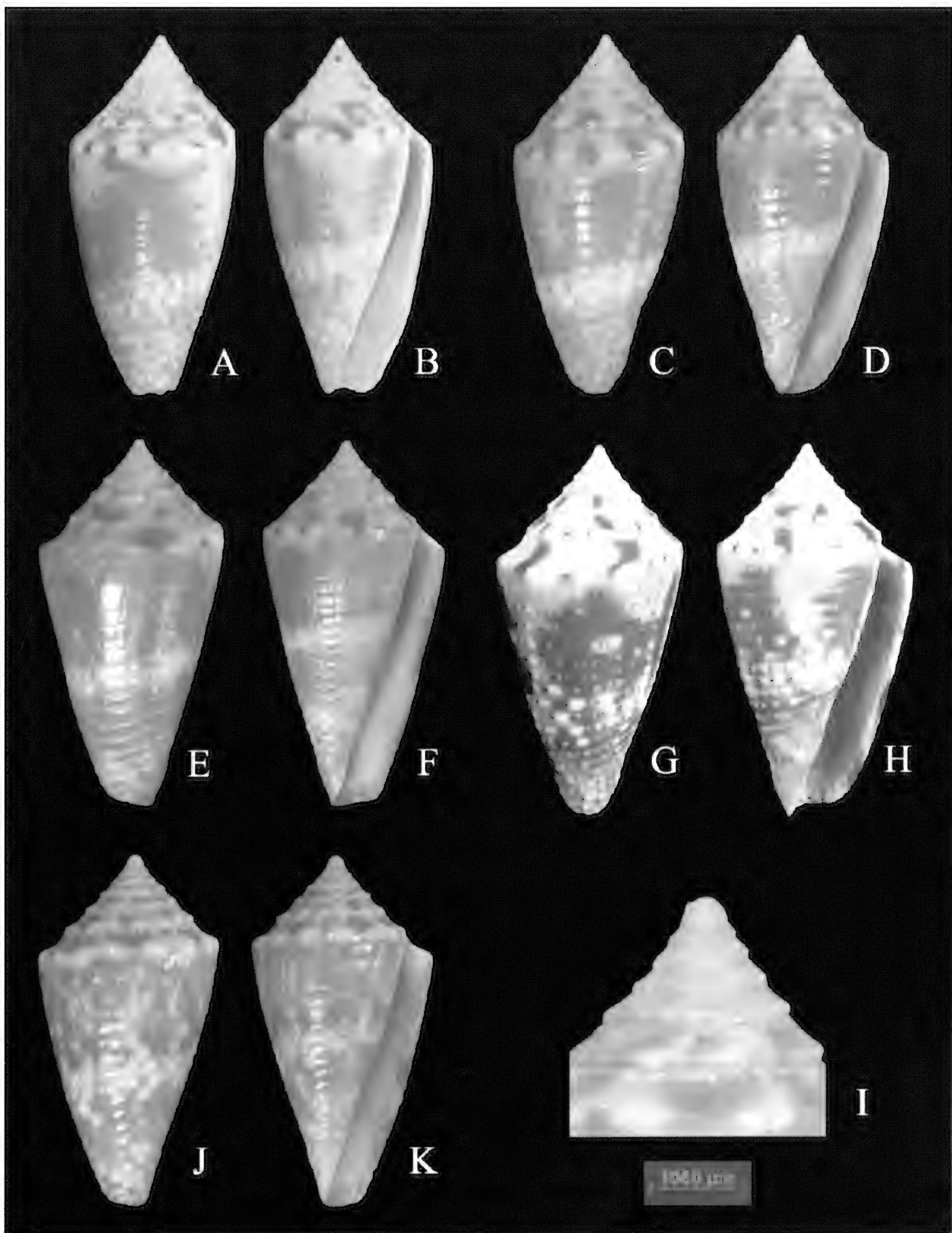


Plate 1. *Jaspidiconus vanini*, Crabos, Oliveira, Almeida, & Queiroz, new species, **A-B** = Holotype measuring 26.7 mm in length, **C-D** = Paratype 1 measuring 21 mm in length (**I** = protoconch view), **E-F** = Paratype 2 measuring 20 mm in length, **G-H** = Paratype 4 measures 19 mm in length; **J-K** = *J. poremskii* specimen for comparison, measuring 15 mm in length.

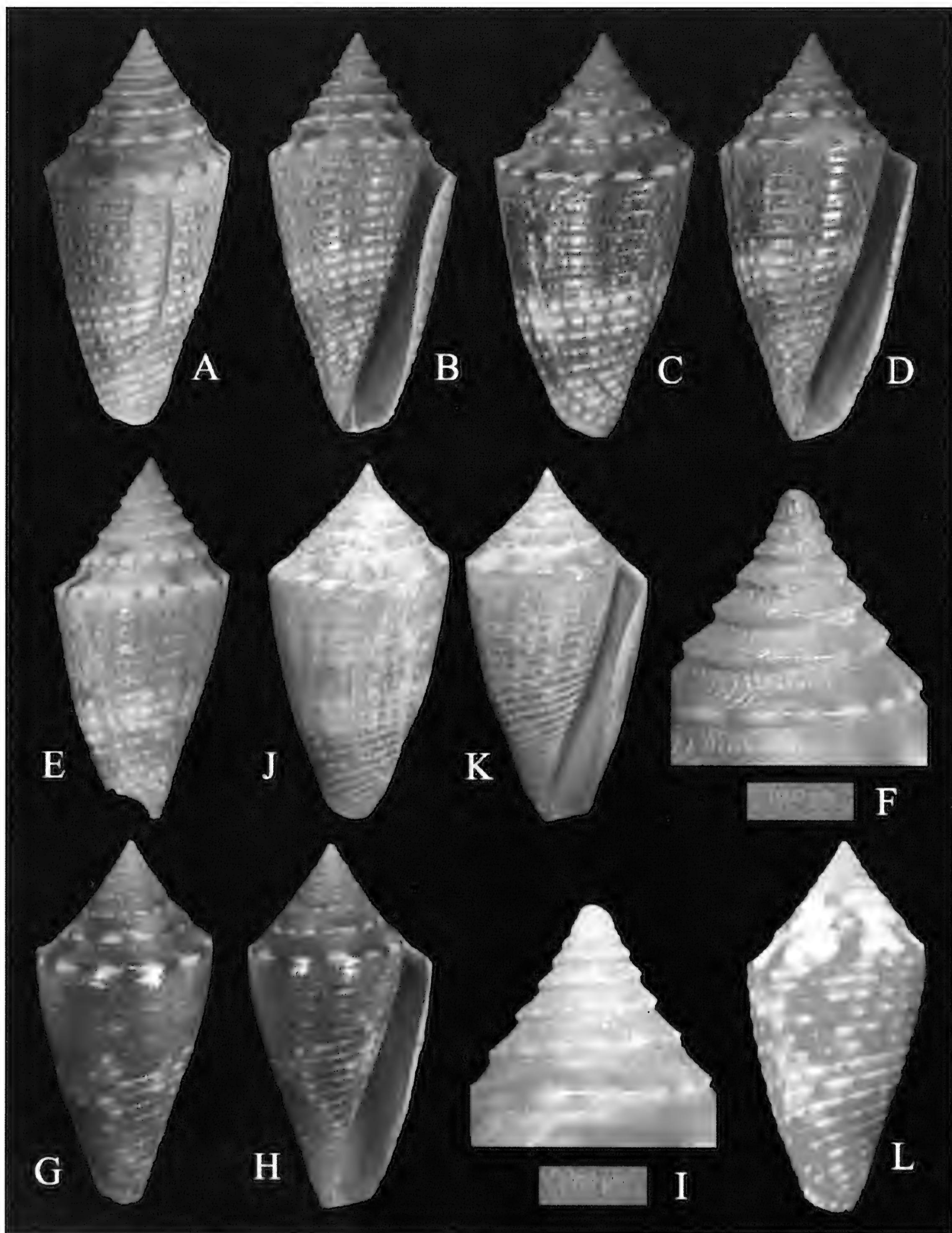


Plate 2. *Jaspidiconus tinharensis*, Crabos, Oliveira, Almeida, & Queiroz, new species, A-B = Holotype measuring length 20.6 mm in length (F = protoconch view), C-D = Paratype 1 measuring 20.9 mm in length, E = Paratype 2 measuring 20.7 mm in length; G-H = *J. marinae* measuring 21 mm in length (I= protoconch view); J-K = *J. simonei* measuring 23 mm in length; L = *J. ogum*, holotype measuring 15 mm in length, image from original article (used with permission).

## Two new species of *Barycypraea* (Gastropoda: Cypraeidae) from the Miocene of Java, Indonesia

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**ABSTRACT** Two new species of *Barycypraea* Schilder, 1927 described from the middle Miocene Epoch on Java, Indonesia. The new species are compared to 140 specimens of related congeners belonging to *Barycypraea* using a morphological analysis concerning outline, callosities, extremities and teeth. The study includes a discussion of the type locality and the site's stratigraphy.

**KEY WORDS** Gastropoda, Cypraeidae, *Barycypraea*, *abbasi*, *alessandrodovesi*, Miocene, Nyalindung, Indonesia.

### INTRODUCTION

The superfamily *Cypraeoidea* was founded by Rafinesque in 1815 and today consists of five families, all closely linked to marine ecosystems. In the family *Cypraeidae*, some authors still place all species in the single genus *Cypraea*. Linnaeus, 1758, sometimes recognising subgenera, and others prefer using separate genera (e.g. Lorenz, 2002). Six subfamilies are recognised in the taxonomy of Bouchet *et al.* (2017), together sharing 77 genera of recent and fossil species, among which there is the genus *Barycypraea* Schilder, 1927 with one living and nine extinct species. Seven of those nine extinct species are presented in this discussion.

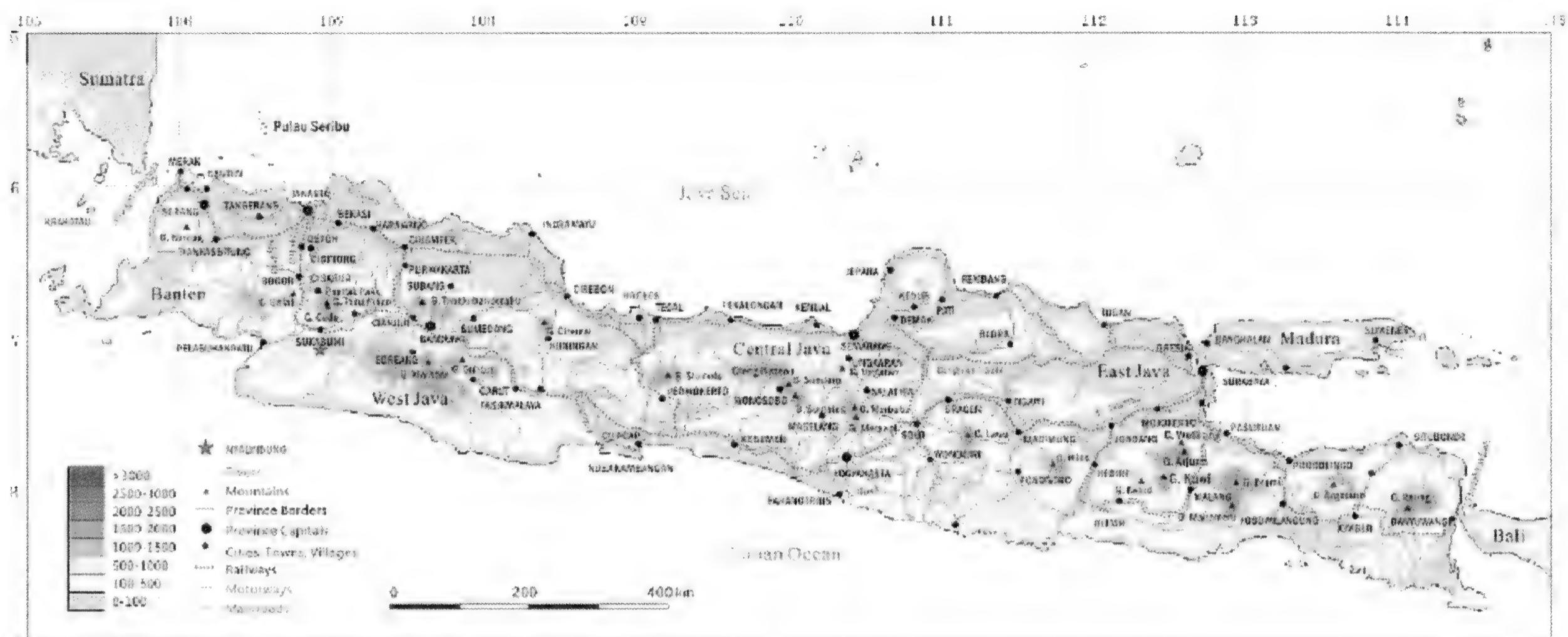
The genus *Barycypraea* is characterized by medium-sized (generally length < 70 mm) robust and calloused shells. The distinctive features of the fossil species of *Barycypraea* are: outline, dorsal callosities, extremities and teeth (Fehse, 2012). Three fossil shells found in Nyalidung District, West Java, Indonesia were examined and compared with 140 specimens of *Barycypraea* spp. from the same site. The study found the new fossils discovered have an outline, callosities, extremities and teeth that are

not attributable to previously described *Barycypraea* species. Therefore, it is justified to describe these species as new to science, namely *Barycypraea abbasi* n.sp. and *Barycypraea alessandrodovesi* n.sp.

### GEOLOGICAL SETTING

The Sunda convergent margin in southern Indonesia represents the collision zone of the Sunda plate with the actively moving Indian and Australian plates (Jones *et al.*, 2014). The rocks at such a boundary are crumpled, folded and faulted, causing uplift and frequent earthquakes on the Sunda plate. The subduction of the other plates causes occasional volcanic eruptions from magma feeding the Sunda Arc. Another important aspect of Indonesian geology is alternating changes in sea level caused by successive ice ages and tectonic subsidence or uplift. The result of all these processes is that large areas of marine rocks and sediments are raised to the surface, and often the fossils they contain exposed by earthquakes and erosion.

Java is a large island in the Indonesian archipelago, located on the southern edge of Sundaland (Figure 1). It has undergone a

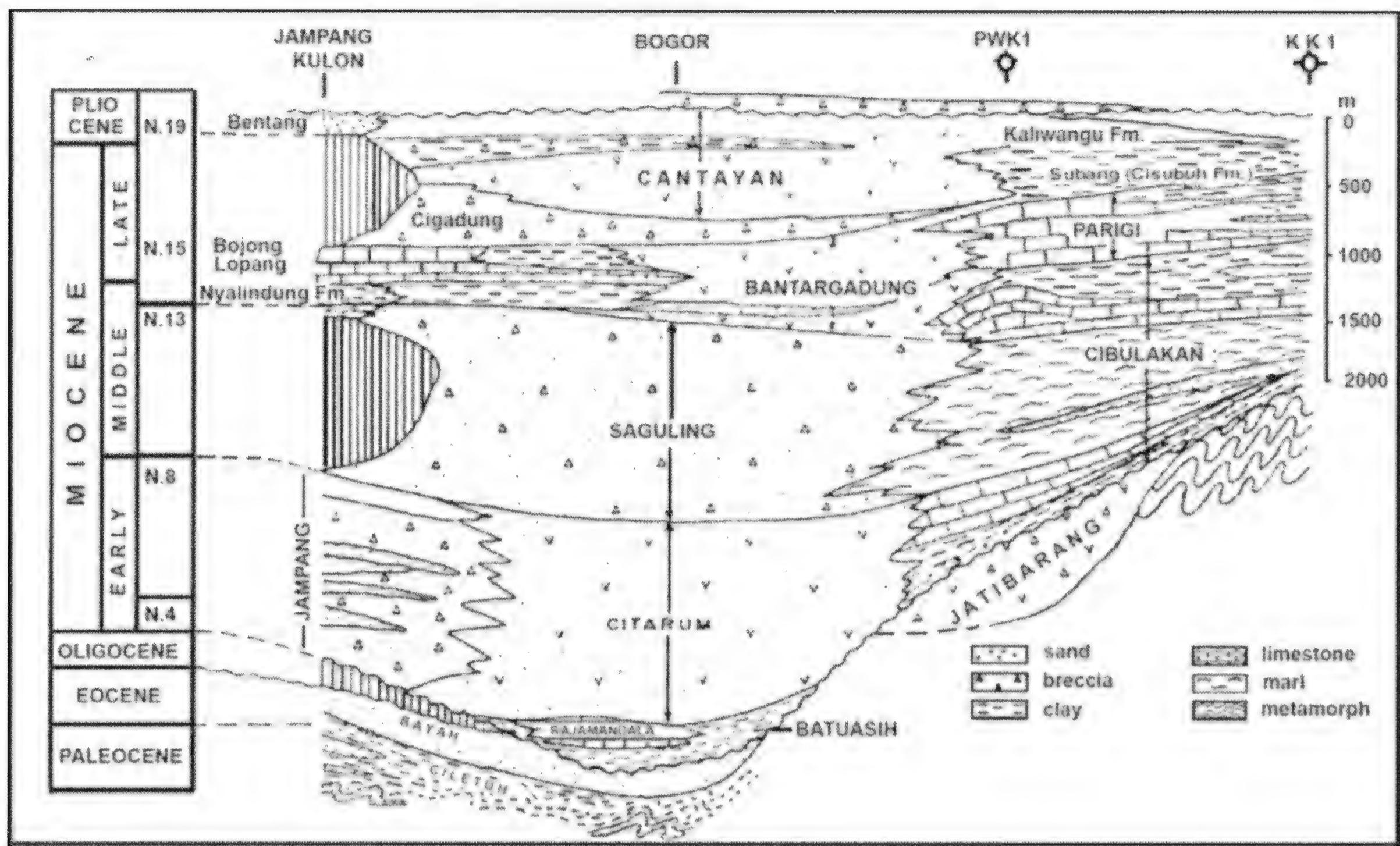


**Figure 1.** Map of Java, Indonesia. The star indicates the Nyalindung study site (OrangeSmile, 2021).

complex geological evolution between the Cretaceous and the late Tertiary (Neogene). During the Upper Cretaceous, a continental fragment rifted from the Australian margin of Gondwana collided with the southern margin of Sundaland, causing subduction to cease and formed the basement of the Southern Mountains in what is now eastern Java (Smyth *et al.*, 2007). Renewal of subduction during the Middle Eocene caused partial melting of this continental fragment to mix with the magma feeding the Southern Mountains Arc. The early Miocene saw a phase of explosive arc volcanism in southern Java, which diminished or ceased by the middle Miocene and allowed widespread carbonate deposition prior to volcanism resuming in the late Miocene, depositing debrites and turbidites in the NW Java Sea (Clements & Hall, 2007). Relative concentrations of shells are of fundamental importance as indicators of the numerous changes in sea level, recorded as faunal changes in depositional sequences (Abbott, 1997; Kondo *et al.*, 1998).

This study is concerned with the siliciclastic shallow marine sediments widespread in West Java. The fossiliferous layer containing the new

*Barycyprea* species is called the Nyalindung Formation (Aswan & Ozawa, 2006; Aswan *et al.*, 2008; Figure 2), or the Nyalindung Beds (Van Bemmelen, 1949). In Jampang Kulon area it is considered as the Nyalindung Member of the Cimandiri Formation (or Complex) (Van Bemmelen, 1949; Sukamto, 1975; Figure 3). It was deposited in the southern part of the Bogor Basin (Van Bemmelen, 1949; Baumann *et al.*, 1973; Figure 2), also known as the Bogor Trough (Koesoemadinata & Siregar, 1984), and is located north of the modern convergence of Sundaland with the Indian and Australian plates (Jones *et al.*, 2014). This formation is exposed along several rivers in western Java, such as Citalahab, Cileungsir, Cigadog and Cijarian (Aswan, 2006; Aswan & Ozawa, 2006; Syarifin, 2011). In the northern part of the Nyalindung District, it stretches along the Cimandiri (Mandiri River) valley to Desa Bantarkalong and the Cimerang highlands, and to the southeast of Bojonglopan (Syarifin, 2011). Depending on location, the lower section of the Nyalindung formation overlies the Lengkong Formation or Jampang Formation, or grades laterally into the Bojonglopan Member (mostly limestone) of the Cimandiri Formation; and the upper section is separated from the Beser



**Figure 2.** Chronostratigraphy and sequence stratigraphy of West Java, includes Planktonic Foraminiferal biozones N4 to N19 (Blow, 1969) (Martodjojo, 1984 in Aswan *et al.*, 2008).

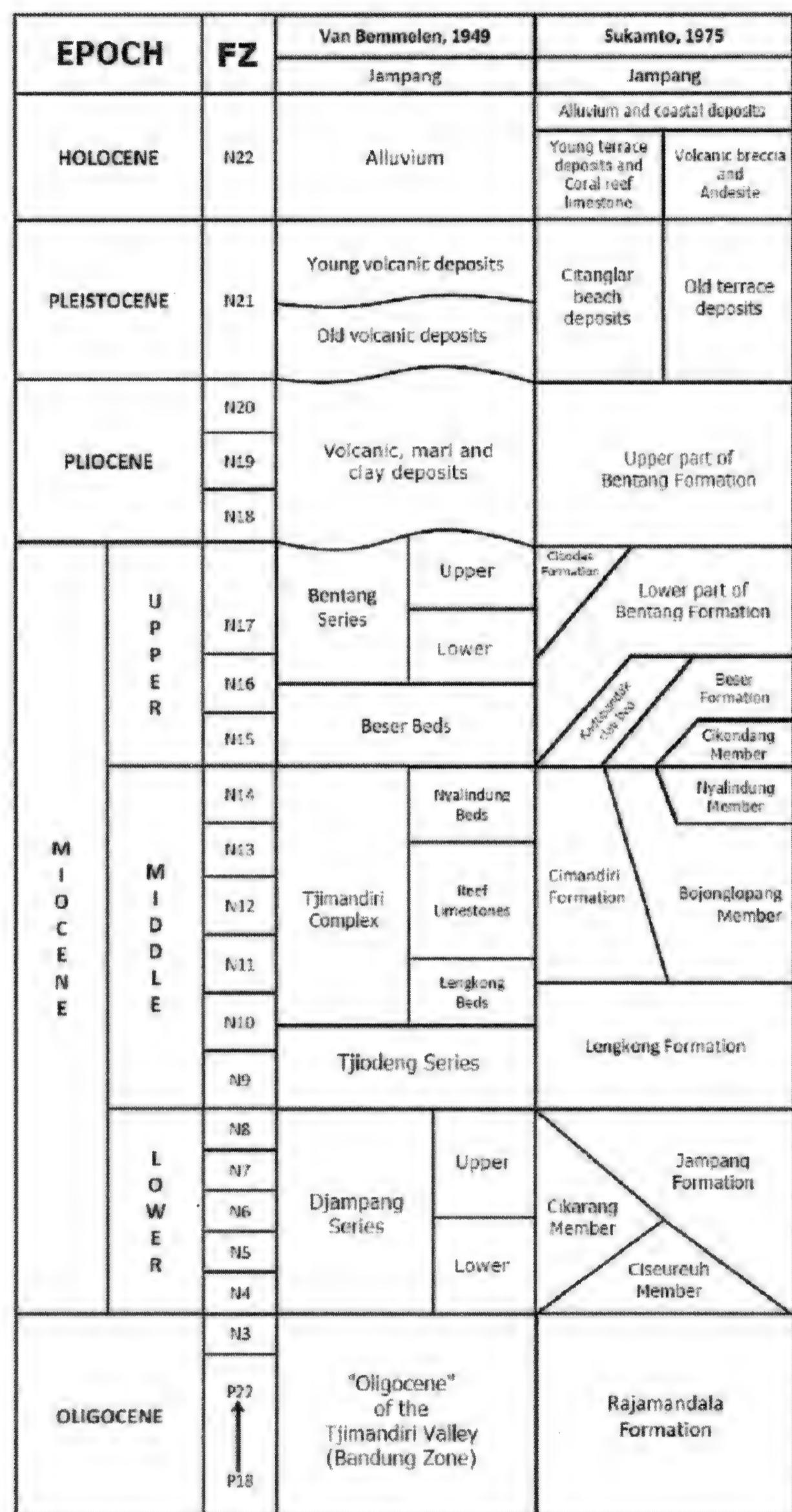
Formation by an unconformity (Sukamto, 1975; Aswan & Ozawa, 2006; Aswan *et al.*, 2008; Syarifin, 2011; Figure 3).

Using molluscan assemblages and index fossils, Oostingh (1938) compiled the Tertiary (Neogene) stratigraphic stages of Java (Pandita *et al.*, 2013). His Preangerian Stage is characterised by species such as: *Vicarya verneuilli callosa* (Martin, 1899), *Turritella angulata* (Martin, 1905) and *Barycypraea caputviperae* (Martin, 1899). Oostingh ascribed the Citalahab (River) near Nyalindung as the type locality of the Preangerian Stage, and designated the type stratigraphy as the Cimandiri Complex (Van Bemmelen, 1949; Kase *et al.*, 2015). The estimated geological age is the middle Miocene (Van Bemmelen, 1949; Aswan, 1997; Aswan & Zaim, 1994; Aswan *et al.*, 2008), equivalent to the Serravallian Stage. This stage is represented by the Nyalindung

Formation in West Java and according to Syarifin (2011) the age estimate for this formation based on foraminifers varies between sites, and covers Blow's Zones N12 to N14 (Van Bemmelen, 1949) or N14 (Sukamto, 1975) (Figure 3). Whereas in sediments containing *Tridacna* at Ci Angsana (River), Batenburg *et al.*, (2011) suggest the foraminiferal fauna indicate an age referable to the last part of the Serravallian and base of the Tortonian, or ~10–13 Ma.

At the Nyalindung research site, mollusc fossils are very abundant in sandstones and siltstones, and also in grey or blackish tuff. Interesting species of the family Cypraeidae, such as *Barycypraea* spp., can be found in abundant numbers. They are found with many other benthic fossils, such as the following gastropod genera: *Phos*, *Thais* and *Liotia* (Van Bemmelen, 1949); *Ancilla*, *Cerithium*, *Columbella*, *Conus*,

*Nassa*, *Nassarius*, *Natica* and *Turbo* (Syarifin, 2011; Dharma, 2005); *Cymatium*, *Melongena*, *Nerita*, *Volema* and *Vasum* (Dharma, 2005). It can therefore be assumed from this assemblage that *Barycypraea* spp. were common at that time and lived in shallow water (Dharma, 2005).



**Figure 3.** Chronostratigraphy and sequence stratigraphy for the study site within the Jampang quadrangle, West Java (Van Bemmelen, 1949; Sukamto, 1975), includes Planktonic Foraminiferal biozones (FZ; Blow, 1969) [Modified and corrected from translation of Syarifin, 2011].

## MATERIALS AND METHODS

The material examined in the present study consists of 3 type shells for the new species, collected between April and May 2019 from the Miocene sediments of Nyalindung (West Java, Indonesia), and 140 specimens of various *Barycypraea* spp. from the same site for comparison (Matteo Dovesi collection, Italy).

In order to better evaluate the morphological variations of the shells described, a batch of 20 specimens for each *Barycypraea* species was retained for sufficient comparison. From these a range of shell morphological characters were analysed for the types of the new species, and the 140 selected samples.

## SYSTEMATICS

- |               |   |  |
|---------------|---|--|
| Class         | : | Gastropoda Cuvier, 1795  |
| Subclass      | : | Caenogastropoda Cox, 1960  |
| Order         | : | Littorinimorpha Golikov & Starobogatov, 1975                                   |
| Superfamily   | : | Cypraeoidea Rafinesque, 1815   |
| Family        | : | Cypraeidae Rafinesque, 1815  |
| Genus         | : | <i>Barycypraea</i> (f.) Schilder, 1927   |
| Type species: |   | <i>Cypraea caputviperae</i> (f.) Martin, 1899 † (type by original designation) |

*Barycypraea abbasi* n.sp. †  
Dovesi and Parsons, 2021  
(Plate 1, Figure 1a)

**Description.** Shell robust, rhombus-ovoidal in outline; centre of gravity shifted rearward where there are two lateral callused protrusions, which make an angular outline. Anterior terminals longer than posterior terminals; posterior terminal tip thicker than half the height of the shell and deeply indented; anterior tip elongated, slightly indented with the extremity facing upwards. Dorsum callused; central area half-moon shaped, convex and smooth. Dorsal

callosities include two posteriorly and one anteriorly, central and slightly irregular. Protoconch and apex covered by callus. Ventrum convex with recurved terminals and rounded margins; ventral margin callused; posterior extremity thick, triangular, protruding and slightly inclined; anterior extremity elongated, straight, with thin margins. Aperture narrow and almost straight, of the same width along the entire length; anal and siphonal canals deeply indented, bordered by a strong protruding callus; anal canal deep, half shell height; siphonal canal deep, one third of shell height. Columella wide and rounded; central part flattened, descending toward apertural opening. Labral lip wide and rounded, inner margin slightly sinuous, straight posteriorly; outer margin callused and more rounded posteriorly. Parietal lip narrow, almost straight, a little callused; inner edge almost straight without denticles. Fossula flattened with two protuberances on the terminal ridge. Medium sized for genus; length exceeds width and height. Labral teeth deep, not very thick and fairly regular, linear; more widely spaced on posterior third, finer and denser anteriorly, and from the inner labral margin they extend 2-3 mm onto the base. Columellar teeth coarser and equally spaced up to half of length, and then become shorter, thick and shallow towards posteriorly. Eleventh columellar tooth non-linear, "comma"-shaped and more distant from previous ones. Pattern obsolete; base light beige, teeth slightly paler and dorsum darker, with the central part greyed.

**Type material.** Holotype: IGF 104323, length 43.8 mm, width 29.1 mm, height 21.0 mm, 20 labral teeth and 15 columellar teeth, preserved in the Museo di Scienze Naturali dell'Università di Firenze (Firenze, Italia). Paratypes (4 shells, not measured, nor figured): Paratype 1 Paris Museum (MNHN.F.A81731); Paratype 2 Jeff

Parsons collection; Paratype 3 John Abbas collection; and Paratype 4 Steven Lie collection.

**Type locality.** From landslides beyond the normal perimeter of the Nyalindung fossil beds in northern part of Nyalindung District, Sukabumi Regency, West Java Province, Indonesia.

**Distribution.** Currently known only from the extended perimeter of the normal 50 x 100 metres fossil bed at Nyalindung.

**Type stratum.** Nyalindung Formation.

**Geological age.** Preangerian (Serravallian) Stage of middle Miocene.

**Etymology.** Name honours John Abbas, who initially recognised this fossil species as new and kindly brought it to Matteo's attention.

*Barycyprea alessandrodovesi* n.sp. †

Dovesi, 2021

(Plate 1, Figures 1b-c)

**Description.** Robust shape, ovoidal shell outline, smooth and sinuous without callus; anterior extremity is longer than the posterior; posterior terminal tip thicker than half of the height of the shell and deeply indented, elongated anterior tip, slightly indented; smooth, rounded, almost spherical dorsum with a convex and smooth central part not restricted; dorsal callosities are two single posterior nodules on both sides of the anal canal; protoconch and apex covered by callus; ventrum slightly convex with rounded edges; ventral callous margins, thick posterior ventral extremity, protruding, slightly inclined; elongated anterior ventral extremity, straight, with thin margins; aperture narrow and curved, of the same width along the entire length; anal and siphonal canals deeply indented, bordered

by a strong protruding callus; anal canal deep half the height of the shell, siphonal canal deep one third of the height of the shell; wide and rounded labral lip, wide and rounded columella with flattened central part descending towards the opening; inner labial margin non-sinuous, curved posteriorly; outer labral margin callused and more rounded posteriorly; thin parietal lip, almost straight, little callused; inner edge almost straight without denticles; flattened fossula with a protuberances in the initial part of the terminal ridge. Medium sized for genus; the length exceeds the width and height. Coarse, shallow labial teeth, not extended on the lip, more spaced and not very evident in the third part towards the posterior extremity, finer and thicker in the anterior extremity; coarse, thick and shallow columellar teeth disappear towards the posterior extremity, not extended on the lip or on the fossula. Light brown uniform colour in the dorsum and base, teeth of the same colour as the base. Almost absent design without mantle lines.

**Type material.** Holotype IGF 104322, length 48.7 mm, width 29.7 mm, height 23.8 mm, 17 labral teeth and 15 columellar teeth, preserved in the Museo di Scienze Naturali dell'Università di Firenze (Firenze, Italia). Paratype length 41.0 mm, width 25.0 mm, height 21.0 mm; 18 labral teeth and 16 columellar teeth, preserved in the Matteo Dovesi collection (Bologna, Italia).

**Type locality.** Northern part of Nyalindung District, Sukabumi Regency, West Java Province, Indonesia.

**Type stratum.** Nyalindung Formation.

**Geological age.** Preangerian (Serravallian) Stage of middle Miocene.

**Etymology.** Named in honour of Matteo's son Alessandro Dovesi, for his seriousness and interest in *Barycyprea* fossils.

## COMPARISON MATERIAL EXAMINED

The following *Barycyprea* taxa have been described from the Miocene Epoch in Indonesia. All descriptions are based on opinions of Fehse (2012) and modified by personal observations.

*Barycyprea beberkiriana* (Martin, 1899)<sup>†</sup>  
(Plate 2, Figure 2a)

**Description.** Oval drop-shaped outline, short anterior aperture and rounded callous posterior aperture, rounded dorsum sometimes a little flattened not restricted by callosities, normally without anterior dorsal nodules but sometimes there are two distinct and not very evident nodules, two posterior dorsal nodules distinct in each side of the anal canal. Absent anterior callosities and absent or poorly evident posterior callosities. Labial and columellar teeth coarse and little extended on each lip.

*Barycyprea caputviperae* (Martin, 1899)<sup>†</sup>  
(Plate 2, Figure 2b)

**Description.** Rather triangular outline, slightly elongated anterior aperture and slightly prominent posterior, irregular dorsum and restricted by callosities, there are two anterior dorsal callosities vertically extended similar to walls separated by a sulcus more or less deep, there are two distinct irregular or deformed posterior dorsal nodules in each side of the anal canal. The dorsal structure is variable and complex. No or sometimes not very evident anterior callosities, irregular posterior callosities. Coarse and close labial teeth, fine and slightly furrowed columellar teeth. The teeth are little extended on each lip.

*Barycypraea murisimilis* (Martin, 1879) †  
 (Plate 2, Figure 2c)

**Description.** Oval drop-shaped outline, slightly elongated anterior aperture and slightly prominent and calloused posterior, rounded dorsum not restricted by callosities, without anterior dorsal nodules, normally without posterior dorsal nodules but sometimes there are two distinct, irregular and not very evident nodules in each side of the anal canal. Absent anterior callosities and posterior absent or poorly evident. Labial and columellar teeth coarse and little extended on each lip.

*Barycypraea orangensis* (Beets, 1942) †  
 (Plate 2, Figure 2d)

**Description.** Triangular outline, short anterior aperture and posterior slightly prominent, flattened dorsum, with rectangular or circular shape, restricted by callosities, single dorsal anterior nodule with vertical development like a wall without groove, two distinct and irregular posterior dorsal nodules in each side of the anal canal. Anterior callosities absent and posterior prominent and sharp. Coarse labial teeth, fine and spaced columellar teeth, both not very extended on the lip.

*Barycypraea quadrinodosa* (Fehse, 2012) †  
 (Plate 2, Figure 2e)

**Description.** Hexagonal outline, very short anterior aperture and rounded posterior, cross-shaped dorsum restricted by callosities, 4 uniform and distinct dorsal nodules, 2 anterior and 2 posterior in each side of the anal canal. Anterior callosities absent and posterior callosities usually absent, sometimes not very evident. Coarse labial teeth, columellar variable from coarse to fine and distinct.

*Barycypraea subtetragona* (Martin, 1879) †  
 (Plate 2, Figure 2f)

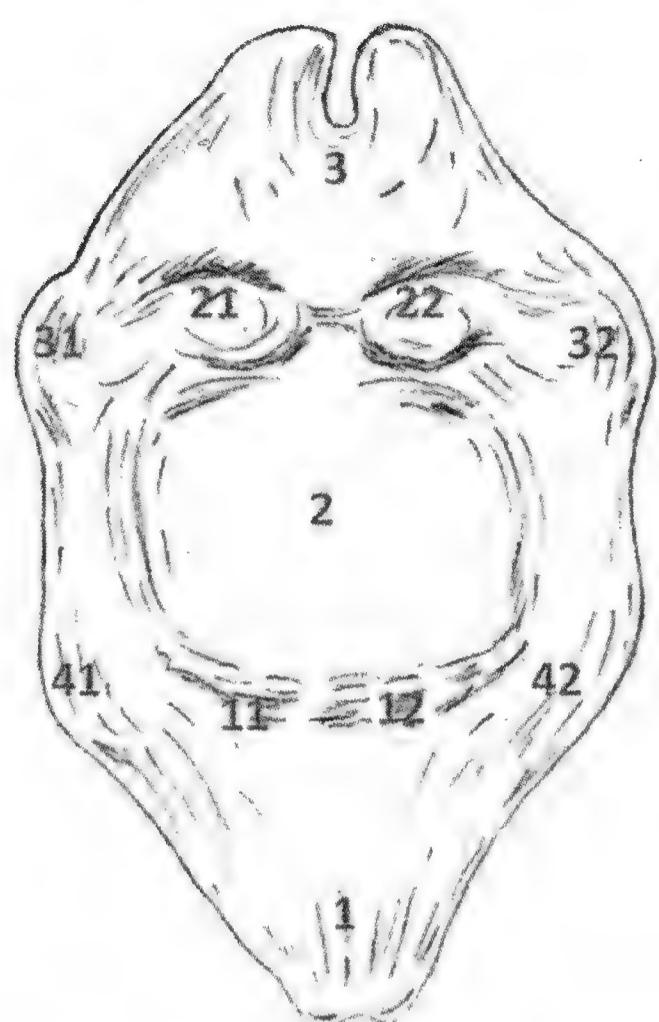
**Description.** Rhomboid outline, elongated anterior and slightly prominent posterior aperture, rounded dorsum not restricted by callosities, anterior dorsal nodules absent and 2 posterior not very evident in each side of the anal canal. Anterior callosities absent sometimes not very evident, not very evident posterior ones. Coarse labial and columellar teeth not very extended on the lip. This species has an intermediate form between *B. beberkiriana* and *B. murisimilis*, with more rounded dorsum.

*Barycypraea suryai* (Beets, 1942) †  
 (Plate 2, Figure 2g)

**Description.** Triangular outline, very short anterior aperture and flattened posterior, flattened dorsum with circular or rectangular shape restricted by callosities, single anterior dorsal nodule vertical like a wall that extends from margin to margin, distinct and roundish posterior nodules in each side of the anal canal. Anterior callosities absent sometimes not very evident, irregular posteriors. Coarse and dense labial teeth, fine and spaced columellar teeth, both extended on the lip.

## DISCUSSION

The distinctive aspects of *Barycypraea* fossils from Indonesia are: shell outline (shape), dorsal callosities, extremities and teeth. The dorsal callosities and shape help in distinguishing the taxa (Fehse, 2012). It is useful to refer to the drawing in Figure 4 when comparing the new species with previous taxa. A summary of the distinctive features of Indonesian *Barycypraea* are given in Table 1 for ease of comparison.



**Figure 4.** Dorsal features of *Barycypraea* species discussed, marked by the following numbers: (1) anterior extremities, (2) dorsum, (3) posterior extremities, (11-12) anterior nodules, (21-22) posterior nodules, (31-32) posterior callosities, and (41-42) anterior callosities. (Illustration by M. Dovesi, modified from Schilder, 1939 and Fehse, 2012).

*Barycypraea abbasi* n.sp. has a rhombus-ovoid shape with elongated extremities, raised anteriorly; rounded dorsum with a half-moon shaped central area restricted by a callosity; and a single anterior nodule, all differentiating it from the other species. Also, its teeth are spaced further apart, more so posteriorly, and extend onto each side of the lip, which are different from other *Barycypraea* species.

*Barycypraea alessandrodovesi* n.sp. has an ovoid shape with elongated extremities; smooth and almost spherical dorsum with a convex and smooth central part lacking callosities, these aspects are not found in the other *Barycypraea* species. Its posterior extremities are prominent and elongated, also different from other species.

This set of four morphological characteristics (outline, dorsum, nodules and teeth) is not attributable to the other *Barycypraea* taxa, and characterise the two new species from the middle Miocene Nyalindung Formation in West Java, Indonesia.

## ACKNOWLEDGEMENTS

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## LITERATURE CITED

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		<i>Barycypraea</i> sp.								
		<i>beberkiriana</i>	<i>caputviperae</i>	<i>murisimilis</i>	<i>orangensis</i>	<i>quadrinodosa</i>	<i>subtetragona</i>	<i>suryai</i>	<i>abbasi</i>	<i>alessandrodoresi</i>
Dorsal structure	Outline	Drop	Triangular	Drop	Triangular	Hexagonal	Rhomboidal	Triangular	Rhomboidal	Ovoidal
	Anterior aperture (1)	Short, tapered	Slightly elongated	Slightly elongated	Short	Very short	Elongated	Very short	Elongated, raised	Elongated
	Dorsum (2)	Not restricted	Irregular, restricted by callosities	Slightly rounded	Flat; circular or rectangular, restricted by callosities	Cross like, restricted by callosities	Not restricted	Flat, circular or rectangular, restricted by callosities	Crescent-shaped, restricted by callosities	Rounded, not restricted
	Posterior aperture (3)	Rounded, callous	Slightly prominent	Slightly prominent, callous	Slightly prominent	Rounded, callous	Slightly prominent, callous	Flattened	Prominent, callous	Prominent, callous
	Anterior nodules (11-12)	Absent, sometimes two distinct little evident	2 similar to walls divided by groove	Absent	2 similar to wall	2 distinct	Absent	1 similar to wall	1 central in backward position	Absent
	Posterior nodules (21-22)	2 distinct	2 distinct	Absent, sometimes two distinct little evident	2 distinct irregular	2 distinct	2 distinct slightly evident	2 distinct rounded	2 distinct	2 distinct
	Posterior callosities (31-32)	Absent, sometimes slightly evident	irregular	Absent or slightly irregular	Prominent and acuminate	Absent, sometimes slightly evident	Slightly evident	Irregular	Slightly present	Absent
	Anterior callosities (41-42)	Absent	Absent, sometimes slightly evident	Absent	Absent	Absent	Absent, sometimes slightly evident	Absent, sometimes slightly evident	Absent	Absent
Ventral structure	Labial teeth	Coarse not extended on the lip	Coarse, closed, little extended on the lip	Coarse little extended on the lip	Coarse not extended on the lip	Coarse little extended on the lip	Coarse not extended on the lip	Coarse, dense, extended on the lip	Clear, distinct, extended on the lip	Coarse not extended on the lip
	Columellar teeth	Coarse little extended on the lip	Fine, close together, little furrowed	Coarse little extended on the lip	Fine, spaced, little extended on the lip	Variables, from coarse to fine and distinct	Coarse little extended on the lip	Fine, spaced, extended on the lip	Fine, distinct, spaced extended on the lip	Fine, little furrowed, little extended on the lip
	Anterior extremities	Short	Short	Slightly elongated	Short	Short	Slightly elongated	Short	Elongated	Elongated
	Posterior extremities	Calloused, rounded	Calloused, squared	Calloused, rounded	Calloused, squared	Calloused, rounded	Calloused, flattened	Calloused, prominent	Calloused, prominent	Calloused, prominent

Table 1. Comparison of the distinctive characteristics of the *Barycypraea* species.

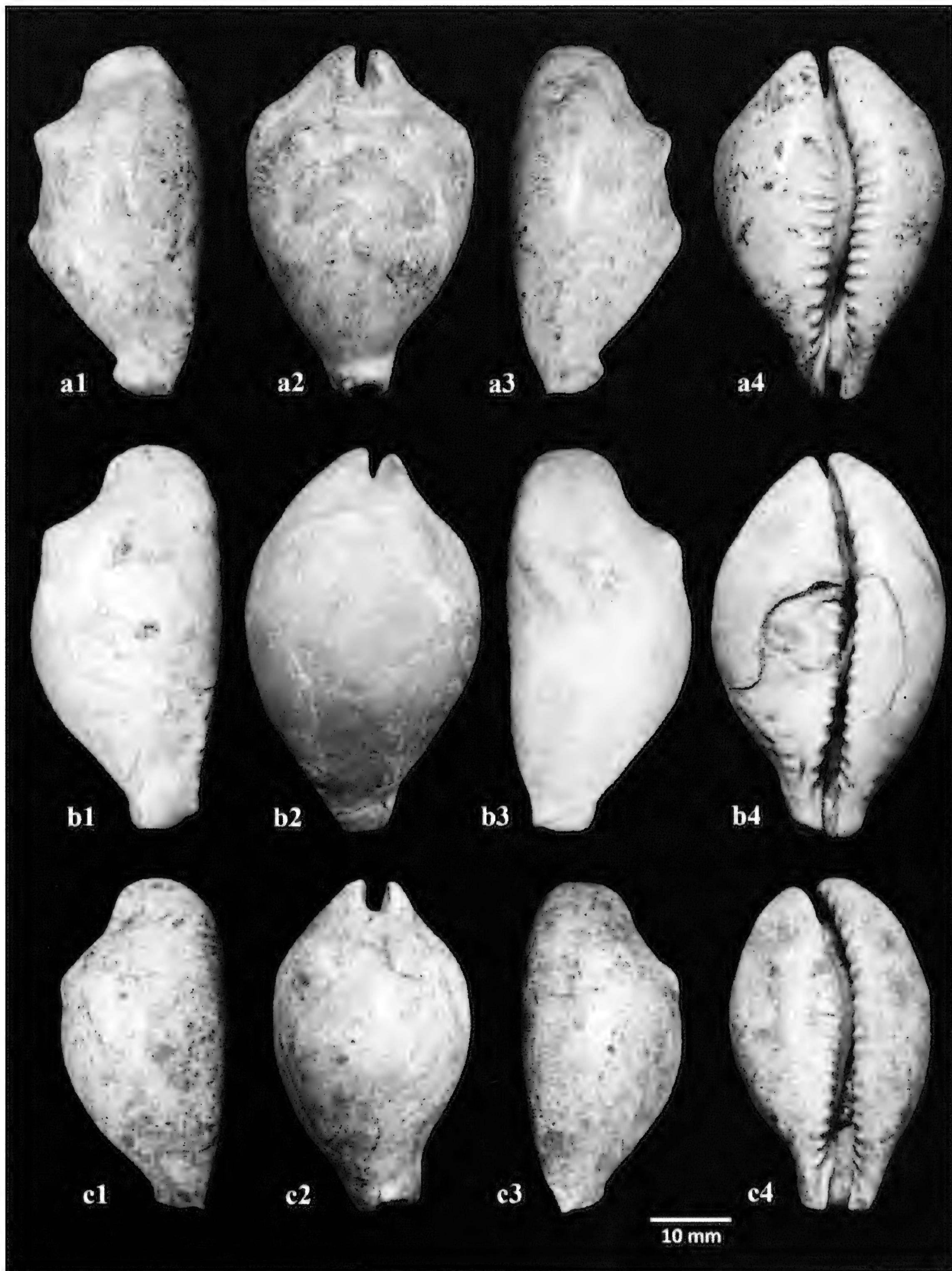


Plate 1. New middle Miocene *Barycypraea* species from Nyalindung, West Java: a) *B. abbasi*. sp. Holotype, IGF104323, 43.8 mm; b-c) *B. alessandrovesi* n. sp., b) holotype, IGF104322, 48.7 mm, and c) paratype 41.0 mm. Various views of the same specimen are designated by letters 1 through 4.



**Plate 2.** Other Miocene *Barycypraea* species from Nyalindung, West Java: **a)** *B. beberkiriana*; **b)** *B. caputviperae*; **c)** *B. murisimilis*; **d)** *B. orangensis*; **e)** *B. quadrinodosa*; **f)** *B. subtetragona*; and **g)** *B. suryai*. Various views of the same specimen are designated by letters 1 through 4.

## The Never Spoken Poignant Connection Between Cuban Tree Snails and Carpentry/Crafts/Art: the case of *Polymita* and *Liguus*

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**ABSTRACT** The extinction of endemic Cuban tree snail colonies are shown to be directly caused by habitat fragmentation due to deforestation. Hardwood extraction and exploitation started in the 16<sup>th</sup> century and has steadily increased throughout the Cuban archipelago. This article is the first investigation into the connection between overexploitation of natural resources by local communities and the extinction of Cuban tree snail colonies. The authors have compiled a list of 345 hardwood trees species, many of which have been clear cut and over used by Cuban farmers, carpenters, artists and crafts people. Of those hardwood tree species, 84 species are known to be host plants for endemic Cuban *Liguus* and *Polymita* tree snails. Since the late 1960s, there has been an accelerated demand for hardwood for traditional craftworks. That demand became more aggressive after the opening of the country to international tourism in the 1990s. This desire for exotic hardwoods has endangered both the precious hardwood tree species and the endemic tree snail species that inhabit them. It is our hope that with the development of field guides on endemic Cuban hardwood tree species that educators can raise awareness of this issue while discouraging unmanaged or uncontrolled harvesting of these hardwoods in Cuba. Encouraging artists and crafts people to create miniature wood sculptures could be an alternative sustainable solution.

**KEY WORDS** Cuban tree snails, *Polymita*, *Liguus*, traditional craftworks, ethnobotany, woodworks, carvings

### INTRODUCTION

The Cuban archipelago contains one of the most diverse and remarkable molluscan land snail fauna in the world (González-Guillén, A., 2008). Currently, more than 1,400 species of land snails have been described from this region (González-Guillén, 2019). Of those, approximately 230 species of closely related land snails are co-dependent on primary and secondary hardwood forests (Mesa, 1986; González-Guillén, 2014; González-Guillén, 2018). Among these strict arboreal species, the genera *Liguus* (Montfort, 1810) and *Polymita* (Beck, 1837) stand out because of their beauty,

color, and polymorphism. Many people in the scientific community contend that this is the reason for their over-collecting resulting in their population declines; this is only partially true. Our research indicates that a major reason for the extinction of many of these populations is forest fragmentation and habitat loss due to overexploitation of hardwood tree species.

The flora of the Cuban archipelago has more than 7,000 species of plants, of which 52.4% are endemic. Over millennia, Cuban herbivorous tree snails evolved rapidly to fill specialized niches among a broad assortment of plants, corticolous lichens and fungi, leading to

specialization between endemic snails and plant host species. Some Cuban tree snail species adapted to environments near sea level (e.g., genera *Coryda*, *Liguus*, *Polymita*, *Helicina*), and others adjusted to environments at higher elevations (e.g., *Cysticopsis lessavillei*). Nevertheless, despite this incredible adaptive radiation, virtually all Cuban arboreal land snail species are now at risk of extinction due to threats to their habitats. Since the 16<sup>th</sup> century, when Cuba was almost entirely covered by exuberant primary forests, deforestation and exploitation of endemic hardwood species have now reduced these forests to less than 15% (Risco, 1995).

Many studies have been published regarding the history of the Cuban forests (e.g. Zanetti & García, 1976; Risco, 1995; Monzote, 2005, 2007, 2008). Obviously some ecosystems, more than others, were cleared or modified for human purposes such as livestock breeding, sugarcane production, coal mining, railroad construction, infrastructure, agriculture (e.g., exotic vegetables, fruits, roots, grains, tobacco, coconut, cocoa, and coffee), as well as rural expansion and development. In 1994, zoologist Gilberto Silva Taboada wrote about the reduction of forested areas on the island stating that “the modification of the Cuban landscape has been tripled since 1959 by human causes.”

A large number of trees from coastal xerophytic shrubland, semideciduous forests, evergreen forests, moist forests, gallery forests and mountain rainforests were cut down for their precious woods. Colonial houses, palaces and country estates were built and decorated utilizing these precious Cuban hardwoods. They were also used to decorate famous buildings like the Empire State Building in New York and El Escorial Palace in Madrid (the later utilized ebony from the Baracoa forests).

*Liguus* and *Polymita* have been studied since the 19<sup>th</sup> century. The first reports identifying specific host plants for these genera appeared in the 1930's (J. Natenson letters to C. de la Torre), and the first extinction concerns were raised in the 1940's [letters to C. de la Torre (March 7<sup>th</sup> and May 14<sup>th</sup>, 1942); Jaume, 1943; M. L. Jaume handwriting from Minutes between 1942-1954; Lippincott, 1954]. Increased attention to extinction risks faced by *Liguus* and *Polymita* began in the 1980s and continues to this day (Milera & Martínez, 1979, 1984, 1987; Milera, 1997, 1999; Fernández-Velázquez & Navarro, 1998; Reyes-Tur & González-Rodríguez, 2003; González-Guillén, 1998, 2014, 2018; Fernández-Velázquez, A. et al. 2001; Almaguer, et al., 2002; Esteva-Morales, 2012.). Because of this, the association between the host plant hardwood tree species and their endemic *Liguus* and *Polymita* species has been well documented.

Other Cuban Cepolidae genera like *Hemitrochus*, Swainson, 1840, *Eurycampta*, Von Martens, 1860, *Jeanneretia*, L. Pfeiffer, 1877 and *Coryda*, Albers, 1850, which seem to use an impressive wide variety of host plants, and *Cysticopsis* Mörch 1852, require more research on their host plant relationships. The same studies are needed for other families of Cuban arboreal land snails.

Very few papers have addressed precious Cuban hardwoods and their use in crafts and sculptures (Martínez et al., 1987; Martínez, 2006). Only one study has been published on Cuban tree snails and their feeding habits on lichens and fungi on specific hardwood tree species (Reyes-Tur et al., 2020).

## MATERIAL AND METHODS

We reviewed all of the literature related to *Liguus* and *Polymita* host plant species and cross-referenced it with our research on

hardwood tree species which have been exploited in Cuba since the 16<sup>th</sup> century. We assembled all of the collected data from these sources including our own, Roig's Botanical Dictionary (2014 edition), which provided additional crucial information, other literature that supplied relevant facts about foreign or local precious hardwood species used centuries ago in cabinet making and sculpture as well as fieldwork experience of craft people known to the first author, who is also a sculptor from the Cuban Association of Artisans and Artists (ACAA), into a database and updated the host-plant species names and their synonymy using Greuter & Rankin (2016).

## DISCUSSION

As far as we know, no prior publication has assessed the impact of the exploitation of precious hardwood species by the carpentry industry, commercial craftsman and sculptors in relation to the impact on Cuban endemic tree snail populations. After an exhaustive analysis we grouped 345 trees species that have been exploited in Cuba; several of these tree species are critically endangered or surviving as relicts in areas where they were once widespread.

Approximately 84 of those 345 tree species are recorded as specific or occasional host plants for *Liguus* and *Polymita* tree snails: *Ampelocera cubensis* (ULMACEAE); *Amyris balsamifera* (RUPPIACEAE); *Bourreria succulenta*, *Cordia alliodora*, *C. sebestena*, *Ehretia tinifolia* (BORAGINACEAE); *Brya ebenus\**, *Caesalpinia bahamensis*, *Dichrostachys cinerea* (= *D. glomerata*), *Gliricidia sepium* (= *Lonchocarpus sepium*), *Haematoxylum campechianum*, *Lysiloma latisiqua*, *L. sabicu*, *Piscidia piscipula* (= *Ichthyomethia piscipula*) (FABACEAE); *Bucida buceras* (COMBRETACEAE); *Calycophyllum candidissimum*, *Exostema caribaeum*,

*Guettarda calyprata\**, *G. longiflora* (RUBIACEAE); *Canella winterana* (= *Canella alba*) (CANELLACEAE); *Casearia aculeata* (SAMYDACEAE); *Cedrela cubensis*, *C. odorata* (= *C. mexicana*) (MELIACEAE); *Celtis trinervia* (CANNABACEAE); *Chrysobalanus icaco*, *Chrysophyllum oliviforme*, *Ch. cainito* (CHYSOBALANACEAE); *Coccoloba caesia\**, *C. diversifolia* (= *C. laurifolia*), *C. praecox\**, *C. reflexa\**, *C. retusa\**, *C. uvifera* (POLYGONACEAE); *Colubrina arborescens* (= *C. ferruginosa*) (RESEDACEAE); *Conocarpus erectus* (CNEORACEAE); *Diospyros crassinervis* subsp. *kubal\**, *D. grisebachii\** (EBENACEAE); *Sideroxylon salicifolium* (= *Dipholis salicifolia*), *Manilkara zapota* (= *M. grisebachii*), *Pouteria aristata\**, *Sideroxylon americanum*, *S. cubense* (= *Dipholis cubensis*), *S. foetidissimum* subsp. *foetidissimum* (= *Mastichodendron foetidissimum*), *S. horridum*, *S. salicifolium* (*Dipholis salicifolia*) (SAPOTACEAE); *Drypetes alba* (= *D. incurva*); *D. lateriflora*, *D. mucronata* (PUTRANJIACEAE); *Erythroxylum areolatum*, *E. confusum*, *E. rotundifolium* (= *E. suave*, = *E. spinescens*), *E. rufum*, *E. havanense* (ERYTHROXYLACEAE); *Eugenia axillaris*, *E. galalonensis*, *E. glabrata*, *E. heterophylla\**, *E. monticola* (= *E. buxifolia*, *E. foetida* var. *parvifolia*), *E. rhombea* (= *E. foetida* var. *rhombea*), *Psidium guajava* (MYRTACEAE); *Guaiacum officinale*, *G. sanctum* (ZYGOPHYLLACEAE); *Guapira obtusata* (= *Torrubia obtusata*) (NYCTAGINACEAE); *Guazuma ulmifolia* (= *G. tomentosa*) (BYTTNERIACEAE); *Gymnanthes lucida* (EUPHORBIACEAE); *Hypelate trifoliata* (SAPINDACEAE); *Jacquinia keyensis*, *J. aculeata* (THEOPHRASTACEAE); *Krugiodendron ferreum* (RHAMNACEAE); *Chionanthus domingensis* (= *Linociera domingensis*, = *Mayepaea domicensis*), *Ch. ligustrinus* (= *Linociera ligustrina*) (OLEACEAE); *Maytenus*

*buxifolia* (CELASTRACEAE); *Metopium toxiferum* (ANACARDIACEAE); *Oxandra lanceolata* (ANNONACEAE); *Phyllanthus epiphyllantus* subsp. *epiphyllantus*\*; *Savia sessiliflora* (PHYLANTACEAE); *Phyllostylon rhamnoides* (= *Ph. Brasiliensis*) (ULMACEAE); *Rhizophora mangle* (RHIZOPHORACEAE); *Talipariti elatum* (= *Hibiscus elatus*) (MALVACEAE); *Terminalia diptera*\* (COMBRETACEAE); *Zanthoxylum coriaceum*, *Z. flavum* (RUTACEAE). We expect that this list will grow as research on these two genera continues. In addition, these species may also be hosts to other arboreal tree snails, which are not the focus of this paper.

It appears that these land snail genera prefer plant species with smooth barks where corticolous lichens develop (e.g., *Eugenia*, *Lysiloma*, *Savia* and *Senna*). Other *Liguus* and *Polymita* host tree genera that have been among the most frequently exploited hardwood species since the 19<sup>th</sup> century (e.g., *Manilkara*, *Diospyros*, *Cedrela*, *Mastichodendron*, *Guaiacum*, *Cordia*, *Brya*, *Lysiloma*, *Gymnanthes*, *Bucida*, *Conocarpus* and *Erythroxylum*) are used in cabinetry, furniture, marquetry, crafts and sculpture. Hardwood tree genera such as *Swietenia* (MELIACEAE), *Pera* (PERACEAE), *Tabebuia* (BIGNONIACEAE) and *Pinus* (PINACEAE) that have also been exploited are excluded from this analysis because they are not considered host plants for *Liguus* and *Polymita*.

In Spanish colonial furniture we were able to identify more than 25 endemic hardwood species (Carreras-Rivery, 1998, 2008, 2010). It seems that the most frequently employed Cuban hardwoods by the Spanish and other European furniture and cabinet makers since the 18<sup>th</sup> century were *Swietenia mahagoni* (Caoba del país, Caoba amarilla, Caoba), *Manilkara zapota* (Ácana), *Manilkara jaimiqui* subsp.

*wrightiana*\* (Jaimiquí, Almiquí, Carne de Doncella), *Diospyros caribaea* (Ébano), *Diospyros crassinervis* (Ébano Carbonero, Chicharrón de cuabal), *Diospyros grisebachii* (Ébano negro), *Brya ebenus* (Granadillo, Espino de Sabana, Espino Negro, Romperopa, Ojo de Perdiz), *Guaiacum officinale* (Guayacán, Guayacán negro, Palo santo), *Guibourtia hymenaeifolia*\* (Quiebra hacha, Algarrobo de las Antillas, Curbaril, Caguairán, Coronel, Guaney, Caney), *Lysiloma sabicu* (Sabicú), *Tectona grandis* (Teca), *Gymnanthes lucida* (Yaití, Aité, Aité caracolillo, Aité veteado, Aceitero, Aceitillo), *Tabebuia angustata* (Roble blanco, Roble yugo), *Pera bumeliifolia* (Jiquí, Jiquí de ley, Jequí), *Calophyllum antillanum* (Ocuje, Ocuje colorado, Ocuje hembra), *Bonetia cubensis* (Manglecillo), *Bucida buceras* (Júcaro común, Júcaro de costa, Júcaro amarillo, Júcaro negro), *Conocarpus erectus* (Yana, Mangle botón), *Erythroxylum sp.*, *Zanthoxylum flavum* (Cerillo, Aceitillo, Ayúa Varía, Satín), and *Juglans aff. jamaicensis* (Nogal). At least 8 of these 20 Cuban hardwoods come from trees known to be *Liguus* or *Polymita* host tree species.

Upon review of the *Diario de la Marina* (Navy's Newspaper) from 1865 to 1875 (A Havana tabloid with a section for Trade & Arts), we determined that in the second half of the 19<sup>th</sup> century, most of the wood furniture and musical instruments manufactured in Cuba were exported to Europe and the United States. Apparently, the Louis XV style was in vogue at that time and rosewood (also is known in Spanish as palisandro (*Dalbergia* spp.)), maple and pine (Pino Tea) were popular in the United States. We also found that some local businesses offered furniture and musical instruments restoration. However, the constant mention of local oak, cedar and mahogany in such advertisements does not mean that other Cuban precious woods were not also exploited

or shipped overseas; this merely means that those trees were more often utilized for fine carpentry work.

E. Martínez (2006) mentions some tree species used in woodcrafts and sculptures in Santiago de Cuba municipality (e.g., *Cedrela odorata*, *Diospyros grisebachii*, *Guaiacum officinale*, *Talipariti elatum*, *Brya ebenus*, *Gerascanthus gerascanthoides* (=*Cordia gerascanthus*), *Hymenaea courbaril* (=*Guibourtia hymenaeifolia*), *Manilkara valenzuelana*, *Citrus x aurantium* (= *C. x sinensis*), *Pinus sp.*). Except for a very few, almost all of these species are reported as *Liguus* or *Polymita* host species. It was noted that several of these hardwood species used in making those commercial products came from other provinces, mostly from adjacent Guantánamo province.

Among the most expensive hardwoods today are the species from genera *Guaiacum*, *Diospyros*, *Cordia*, *Dalbergia*, *Guibourtia* and *Brosimum*. In Cuba, the over-exploitation of some of these valued hardwoods for carpentry, wood crafts and sculptures and their relation with the decline of these endemic tree snail populations is not well understood or recognized. Throughout the country these hardwoods can be found in every crafts trade fair, tourists store and art gallery. The problem is that removing host trees as well as other hardwood species that may be used by these endemic tree snails, from the forests causes habitat fragmentation and reduces a population's chance for survival.

*Polymita* and *Coryda* species are more resilient than *Liguus* species, which have longer life cycles and are therefore more susceptible to drastic changes in habitat conditions. Arboreal tree snails are less adaptable than terrestrial land snail species. It is possible that in some ecosystems the growth rate of tree species can

be fast enough to allow them to recover in only a few years after being cleared. Unfortunately, the growth rate of hardwood trees in coastal forests is very slow (e.g., *Guaiacum* can reach 30 centimeters in trunk diameter in about 100 years). Consequently, at the current rate of deforestation, the remaining hardwood tree species and their closely linked endemic tree snail populations are in grave danger of extinction unless there is an immediate and conscious effort to protect these habitats for future generations.

In Cuba, there are no tree worshiping traditions except for the species *Ceiba pentandra* (it's said because of its similarity with the African Baobab tree) and Royal palm *Roystonea regia*. There is a religion in Cuba known as 'Palo' or 'Palo Monte' that is divided into multiple traditions including Kimbisa, Mayombe and Briyumba branches. Palo contains a close bond and awareness of certain plants and trees. Some of these species are hardwoods used in crafts (e.g., *Abarema obovate* (= *Pithecellobium obovale*), *Capparis cynophallophora*, *Capparis ferruginea*, *Senna bicapsularis* (= *Cassia emarginata*), *Exothea paniculata*, *Trophis racemosa*, *Casearia sylvestris*, *Byrsonima sp.*) but very few of these species are *Liguus* and *Polymita* hosts (*Canella winterana*). There's also a religion named 'Santería' of African origin that uses hardwoods in some of its religious items.

There has been a gradual development through the centuries of carving African related images in hardwoods. This has been used to justify an "identity of customary carving", when in fact, it is a market that grew slowly from the late 1960s to the present. Before that time, wood, bronze and stone sculpture was more allied to the art *per se* (Veigas, 2005), and wood was the less utilized medium by the Academy artists, with few exceptions. African related wood crafts in

the 19<sup>th</sup> and first half of the 20<sup>th</sup> century were made mostly for their religious demand, mainly by African descendants. Requests for precious hardwoods were mostly related, as always, to the cabinet making industry and urban or township construction.

In 1978 the Cuban government created the *Fondo Cubano de Bienes Culturales* (Cuban Fund of Cultural Assets, "FCBC") in order to commercialize crafts on a large scale. In the 1990s, this institution launched a network of galleries and stores throughout the archipelago. It must be kept in mind that large-scale commercialization and over-collecting of *Polymita* shells for crafts, with government approval, occurred from the mid-1960s to the early 1990s. Accordingly, during those decades the deadly combination of increasing demand for precious hardwoods, legal over-collecting of shells, and other forest loss caused by the sugarcane industry, agriculture, grazing, mining and infrastructure expansion, led to the significant decline of *Polymita* species. These forces combined to reduce *Polymita* populations more than what had occurred during the first half of the 20<sup>th</sup> century.

In a country that no longer exports precious hardwoods, Cuban Forest Rangers play an important role in regulating and enforcing the laws that protect these woodland territories. However outside these territories, forest rangers have no jurisdiction. When smugglers are able to evade forest rangers and police, they will frequently sell the hardwoods to carpenters and artisans. This naturally leads to hardwood trafficking throughout the country with much of the wood reaching craft fairs as commercial products. This exploitation is more aggressive in some province than others. For example, *Guaiacum officinale* trees are habitual hosts of *Polymita versicolor* in Guantánamo province

coastal and subcoastal range, and is one of the most desirable woods in that region.

Finally, international tourism development has led to even more aggressive exploitation of endemic hardwoods. Yet it is important to mention, that in the last decade, carving wood miniatures is becoming more popular and is now included as a contest category in sculpture events.

## CONCLUSIONS

After 1960, the increase in hardwood crafting was an ongoing trend that matured in the late 1970s and has continued to this day. It seems clear that a significant cause of *Liguus*, *Polymita* and other tree snails' genera populations decline in the last 70 years is due to hardwood demand by crafts people and artisans. Precious hardwoods were used mainly in carpentry and construction in the first half of 20<sup>th</sup> century. This resulted in significant deforestation and forest fragmentation. As a consequence, tree snail populations that utilize these trees as host plants are now threatened with extinction. In addition, the unending demand for selected hardwood species in the second half of the 20<sup>th</sup> century has further decreased their chances for survival.

## RECOMMENDATIONS

The lack of knowledge of endemic Cuban hardwoods species in the wild has become a liability. Forest rangers, crafts people and sculptors in Cuba must learn to identify them and understand that these trees are host plants for a variety of endemic Cuban land snails. A proper field guide of trees is urgently needed. If the artisans and sculptors want to save these precious hardwood species for future generations, they must start working commercially with smaller formats. For

example, instead of carving a single sculpture in a 50 cm block of black ebony, they can sculpt several pieces and even use the remaining splints and dust for inlays. In the end, they will obtain a better return from those several pieces rather than for just one. We understand that not everyone can become a skilled miniature carver and that bigger sizes are desirable as well, but the alternative solution of carving miniatures will help save Cuba's forests as well as the animals that rely on them.

## AKNOWLEDGMENTS

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**Photo credits:** Photos 1-20, 22-32 by Adrián González-Guillén; 33 by Raimundo López-Silvero; and 21 by Quinhua Zhou.

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**PLATES:**

Plate 2 Figures 18-19 Sierra de Gabino, Guane, Pinar del Rio province;

Plate 3 Figures 20-25 Valle de San Carlos, Pinar del Rio province;

Plate 3 Figures 26-28 Sierra de Cristal, Santiago de Cuba and Holguín provinces.

**ADDENDUM:**

Pictures credits: Méndez-Hernández (1-5, 26-27), López-Silvero (6, 8-11, 13-15), Teruel (28), Salas-Pantoja (7), González-Guillén (12, 16-25).



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**Plate 1.** 1: *Polymita picta iolimbata* over *Casearia aculeata*, 2: *Lysiloma latisiliqua*, 3-4: *Liguus fasciatus achatinus* over *L. latisiliqua*, 5: *Coccoloba uvifera*, 6: *P.p. roseolimbata* over *Gliricidia sepium*, 7: *Erythroxylum havanense*, 8: *P.p. iolimbata* over *E. havanense*, 9: *P. muscarum* over *Canella winterana*, 10: *P. muscarum* over *Coccoloba uvifera*, 11: *L.f. guitarti*, 12: *P. sulphurosa* over *Eugenia sp.*, 13: *P. muscarum* over *Eugenia axillaris*.



**Plate 2.** 14: *Sideroxylum salicifolium*, 15-16: *P. sulphurosa* over *Diospyros crassinervis*, 17: *P. sulphurosa* over *Sideroxylum salicifolium*, 18, 21-22: *P. versicolor* over *Guaiacum officinale*, 19, 26: *Guaiacum officinale*, 20: *L.f. achatinus* over *Guaiacum officinale*, 23: *P. sulphurosa* over *Calycophyllum candidissimum*, 24: *Calycophyllum candidissimum*, 25: *P. sulphurosa* over a hardwood tree trunk.

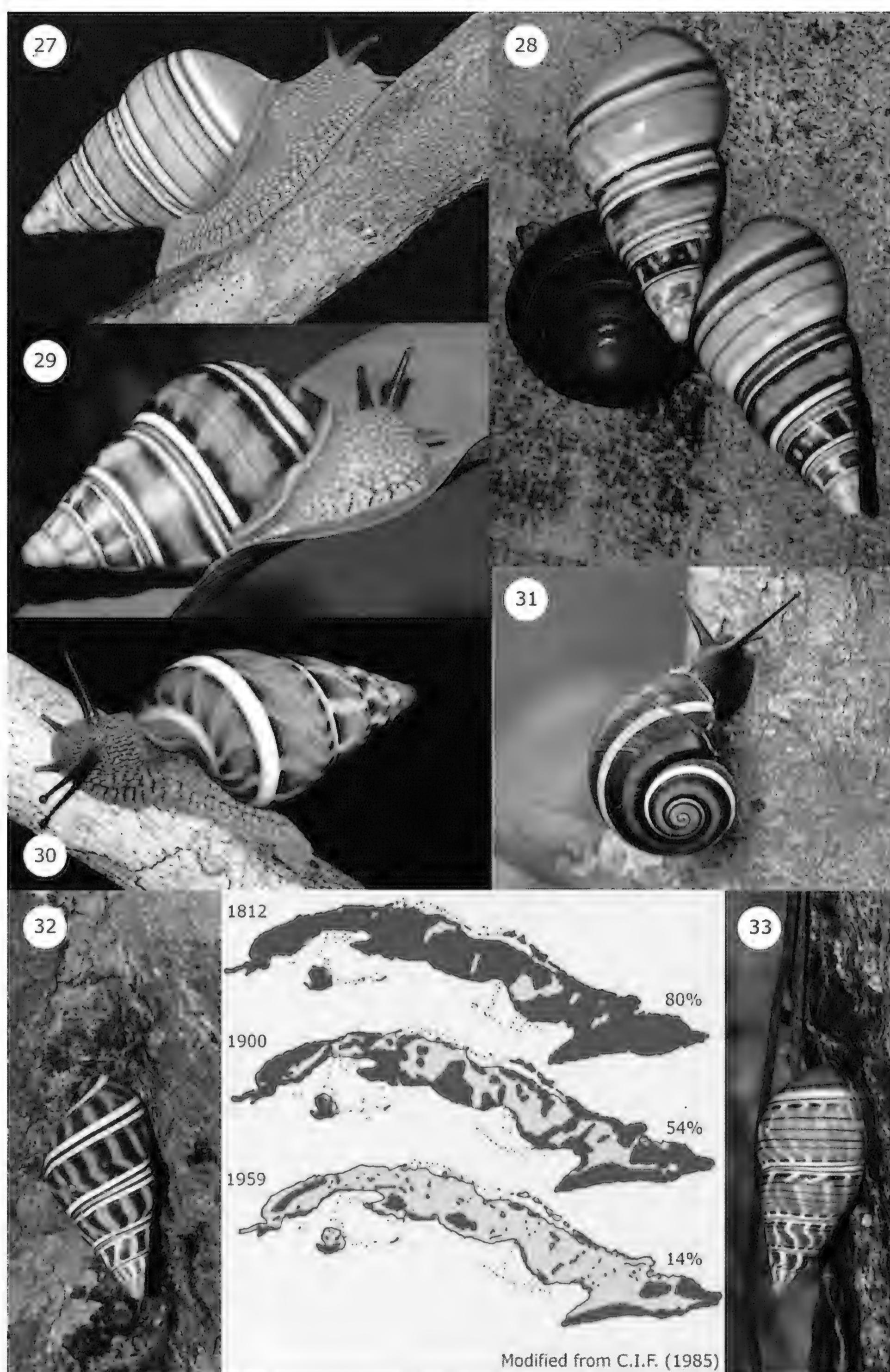


Plate 3. *Liguus* and *Polymeria* over different trees types. 27-29: *L.f. achatinus*, 30: *L.m. fairchildi*, 31: *P.p. iolimbata*, 32: *L.b. pilosbryi*, 33: *L.f. viridis*. Simplified map showing the Cuban archipelago deforestation rate from 1812 to 1959 (Modified from a 1985 Forestry Research Centre map).

## New distributional information about a North Pacific *Crassicardia*

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**KEY WORDS** Aleutian Islands, distribution, Carditidae, *Crassicardia rjabininae*

### DISCUSSION

In sorting through material collected in recent years from the Aleutian Islands, by the National Marine Fisheries Service (NMFS), the junior author came across three lots of a species of *Crassicardia* not present in Coan *et al.* (2000). After reviewing relevant literature and discussing the matter with colleagues, all agree that these specimens represent *Crassicardia rjabininae* (Scarlato, 1955). The specimen from the furthest east location, near Tanaga Island, has been deposited as a voucher at the Santa Barbara Museum of Natural History (SBMNH 174221).

Recent work has demonstrated that the genus *Cyclocardia* Conrad, 1867, had been used for a variety of unrelated Carditidae (Pérez & Giachetti, 2020). As a consequence, the genus *Crassicardia* Savitskii, 1979, was recognized for several North Pacific taxa. Its type species is *Astarte crassidens* Broderip & G. B. Sowerby I, 1829, which had most often been placed in *Cyclocardia*. Other living species now included are *C. crebricostata* (Krause, 1885), *C. isaotakii* (Tiba, 1972) and *C. rjabininae* (Scarlato, 1955). Several fossil species were also included in this genus, which is known from the Pliocene.

The type locality of *Crassicardia rjabininae* is Sovetskaya Gavan (49°43'N). Its previously known distribution is from Avachinskiy Zaliv (52°52'N) in Kamchatka

to Zalif Petra Velikogo (42°43'N) on the Russian mainland, and from Hokkaido (42°) to Iwate Prefecture (40°N) in Japan (Higo *et al.*, 1999; Lutaenko & Noseworthy, 2012; Scarlato, 1981).

The recently discovered material is from the following stations, extending the known distribution of this species eastward:

W of Buldir Island (52°18.5'N, 175°49'E), 325 m, 9 August 1997. (NMFS 23-1997-01-243); 21.6 mm (single valve; not shown).

WSW of Buldir Island (52°10.21'N, 175°04.08'E), 172 m, 8 August 1997. (NMFS 23-1997-01-238); 24.7 mm. (Fig. 1B)

SW of Tanaga Id. (51°30.4'N, 178°33.28'W), 174 m, 23 July 2010. (NMFS 143-2010-01-157); 41.45 mm. (Fig. 1A)

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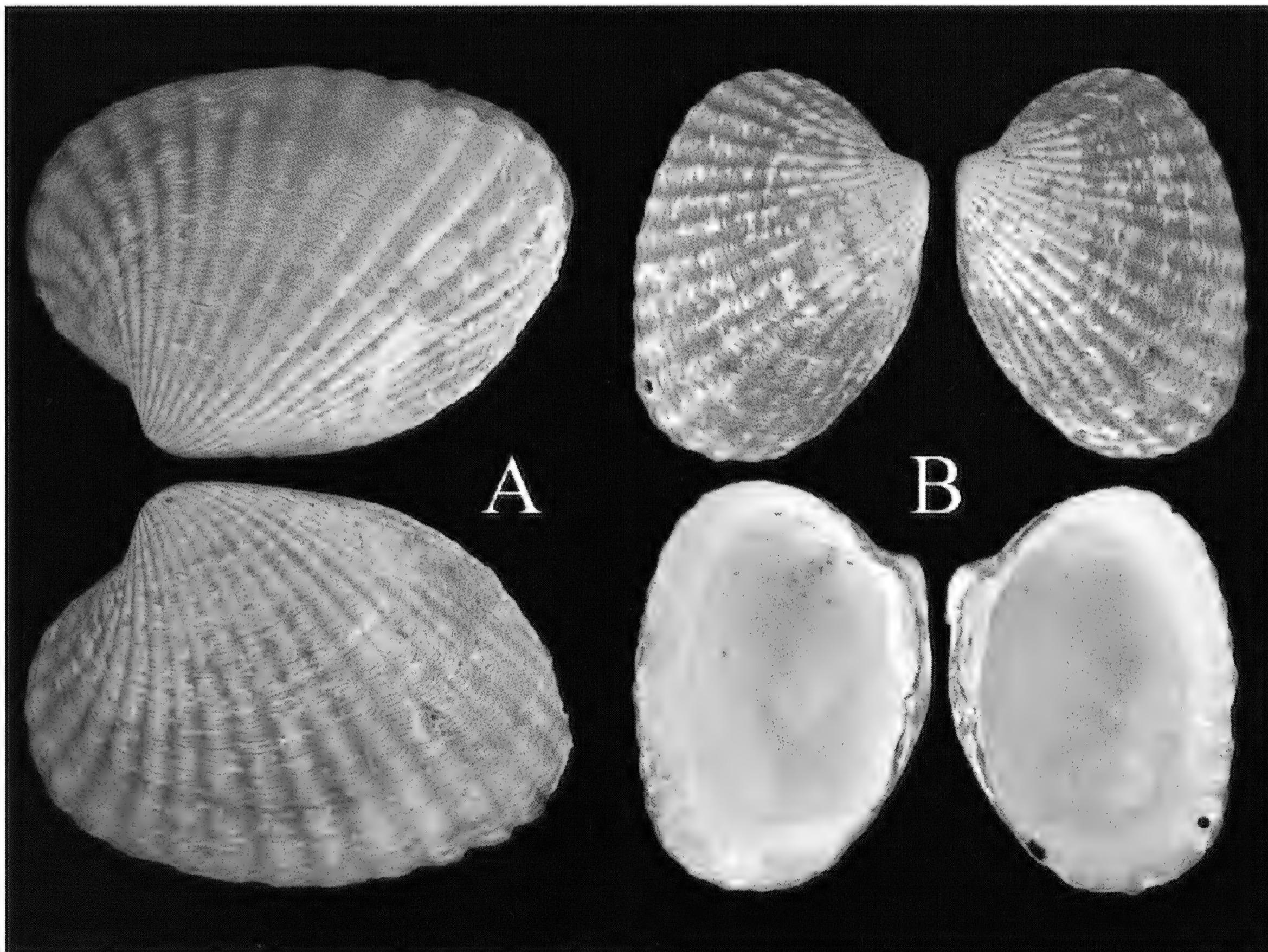
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**Figure 1.** *Crassicardia rjabininae*: A= SBMNH 174221, SW of Tanaga Island, 41.45 mm in length; B= Roger N. Clark Collection - RNC 5055, WSW of Buldir Island, 24.7 mm in length.

## A new species of *Quasimitra* (Gastropoda: Mitridae: Mitrinae) from Indonesia

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**ABSTRACT** Several specimens of a new species of *Quasimitra* Fedosov, Herrmann, Kantor & Bouchet, 2018 were found off Bungin Island, North West of Sumbawa Island in Nusa Tenggara Islands, Indonesia. The shell is different from other species in the family Mitridae Swainson, 1831, and is compared to other species in the genus *Quasimitra* Fedosov, Herrmann, Kantor & Bouchet, 2018.

**KEY WORDS** Mitridae, *Quasimitra*, *Q. houarti*, Sumbawa, Indonesia

### INTRODUCTION

Six specimens of a new species of *Quasimitra* were collected in the end of 2020 and early 2021. These were obtained by a local diver from depths of 25-30 m. Another specimen from the Sofjan Effendy Collection, was dead collected approximately twenty years ago, from Nusa Tenggara Islands.

Based on its shell morphology the new species is here placed in the genus *Quasimitra* Fedosov, Herrmann, Kantor & Bouchet, 2018, and it is compared to *Quasimitra nubila* (Gmelin, 1791), *Q. lamarckii* (Deshayes, 1832), and *Q. hawaiiensis* (Kay E.A., 1979).

### ABBREVIATIONS

MZB	Museum Zoologicum Bogoriense, Cibinong, Bogor, Indonesia
SMF	Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt, Germany
SE	Sofjan Effendy's collection
BD	Bunjamin Dharma's collection

### SYSTEMATICS

Family : Mitridae Swainson, 1831  
Subfamily : Mitrinae Swainson, 1831

Genus : *Quasimitra* Fedosov, Herrmann, Kantor & Bouchet, 2018

*Quasimitra houarti* Dharma, new species  
(Figures 1, 2, 3)

*Mitra nubila nubila* - Dharma, 2005: pl. 43, fig. 7.

**Description.** Shell of average size for genus, height up to 58.5 mm, thick, elongate ovate, spire rather tall and tapering to apex, last whorl large. In all material examined the protoconchs were missing, adult shells averaging 9-10 whorls; spire whorls almost flat or somewhat convex, more convex towards the last whorl, and last whorl slightly inflated; suture shallow, crenulated by termination of radial ribs; base color white, with irregular light brown and brown streaks, and small scattered white spots; streaks reach suture; some earlier whorls whitish; body whorl with three light brown spiral bands, first above aperture posterior, the third vague near bottom above siphonal fasciole, and the second between those two bands; shell sculptured with 28-44 spiral grooves and intersecting with radial striae or microscopic radial ribs; aperture elongate, oblique, angulated posteriorly, slightly inflated at the bottom, height of aperture slightly longer than half

of the shell height; inside of aperture smooth, white; outer lip thickened, glossy, terminating in brown denticles at end of spiral grooves; columella overlaid with white callus, with 5-6 oblique folds; umbilicus closed; siphonal canal slightly recurved, siphonal fasciole sculptured with oblique spiral cords, siphonal notch open.

**Type Material.** Bungin Island, North West of Sumbawa Island in Nusa Tenggara Islands, Indonesia, 25-30 m depth: Holotype MZB Gst. 22.028, height 55.3 mm (Figure 1); Paratype #1 MZB Gst. 22.029, height 53.1 mm (not shown); Paratype #2 SMF 363004, height 49.8 mm (Figure 2); Paratype #3 BD, height 58.5 mm (Figure 3); Paratype #4 BD, height 46.6 mm (not shown). Nusa Tenggara Islands, Indonesia: Paratype #5 SE, height 53.8 mm (not shown).

**Type Locality.** Bungin Island, North West of Sumbawa Island in Nusa Tenggara Islands, Indonesia, 25-30 m depth.

**Etymology.** Named after Roland Houart, Belgium, who has been very supportive and has provided the author with guidance in molluscan systematics.

**Distribution.** Only known from the type locality.

**Discussion.** The new species *Quasimitra houarti* differs from other known *Quasimitra* species by its shell outline, which is elongate ovate with a tapering spire. The spire is proportionately tall, with the outline of the whorls being rather flat or convex, and the body whorl slightly inflated. The shell of *Q. houarti* is much more slender than *Q. nubila* (Gmelin, 1791) and *Q. lamarckii* (Deshayes, 1832). Compared with *Q. nubila* (Gmelin, 1791) (Figure 4) which has relatively more inflated shell outline, more convex whorls,

slightly inflated on the last whorl near suture, deeper suture, and vertical or almost vertical siphonal canal; three specimens examined, two from Mozambique and one from Tonga, have fewer spiral grooves of 19-26. The position of a light brown spiral band located below aperture posterior is different; *Q. nubila* (Gmelin, 1791) has spiral band located slightly below the aperture posterior, while on *Q. houarti* n. sp., the spiral band is quite farther below. In comparison with *Q. lamarckii* (Deshayes, 1832) (Figure 5) that has quite similar shell outline with *Q. nubila* (Gmelin, 1791); *Q. lamarckii* has five spiral bands of spots on the last whorl, one of them is slightly below aperture posterior which is similar with *Q. nubila*. The shell outline of *Q. hawaiiensis* (Kay E. A., 1979) from Hawaii differs from *Q. houarti* in that *Q. hawaiiensis* is elongate fusiform, tall spire and ventricose on the last whorl.

## ACKNOWLEDGEMENTS

I thank Arifin Mulijadi from Bandung who donated a specimen of *Quasimitra lamarckii* (Deshayes, 1832) from Kei Islands, Southern Maluku, and Sofjan Effendy from Jakarta for lending a specimen of *Q. houarti* for this study.

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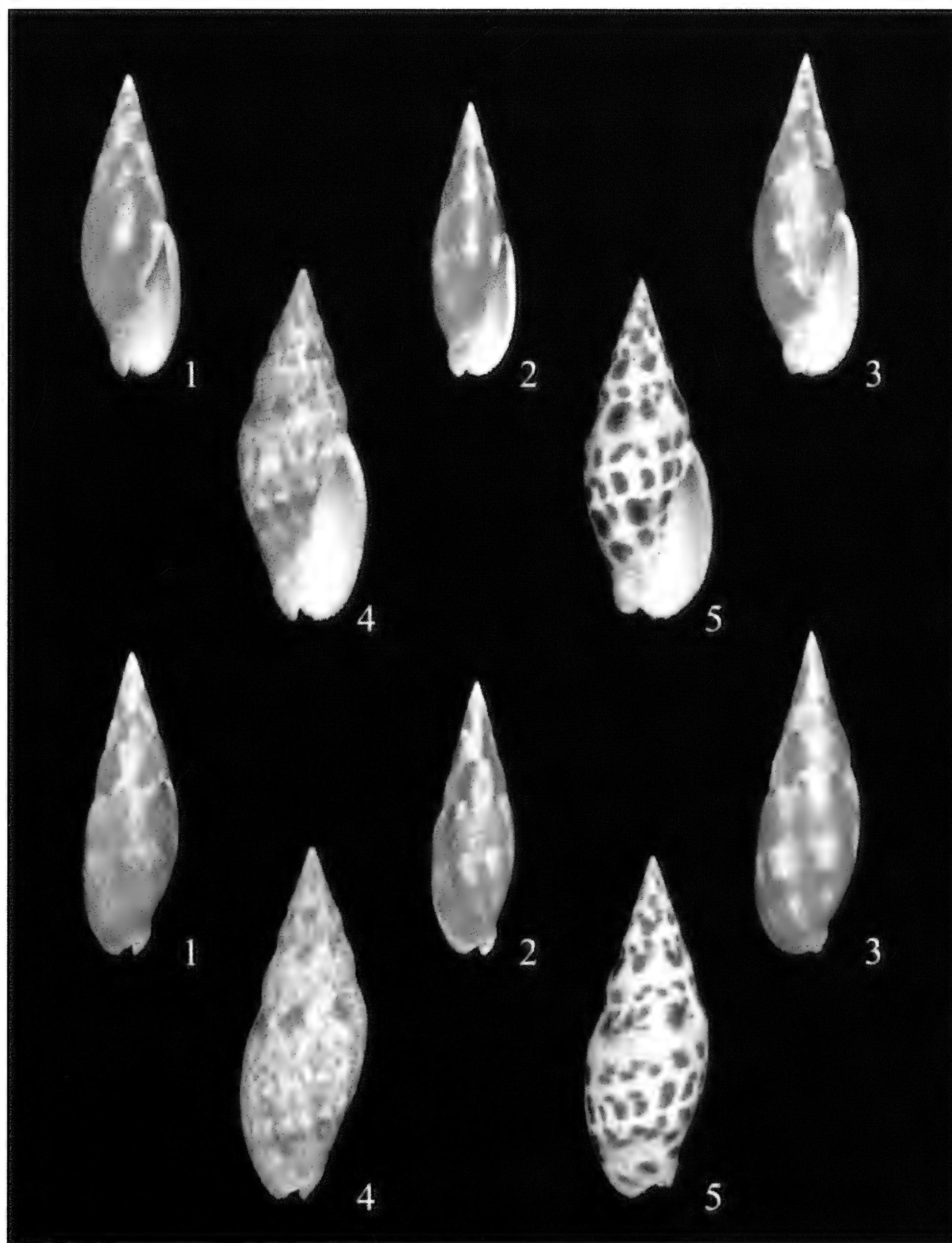
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**Figures 1-3.** *Quasimitra houarti* n. sp., Bungin Island, North West of Sumbawa Island, Nusa Tenggara Islands, Indonesia. **1**= Holotype, MZB Gst. 22.028, height 55.3 mm; **2**= Paratype SMF 363004, height 49.8 mm; **3**= Paratype BD, height 58.5 mm. **Figure 4**= *Q. nubila* (Gmelin, 1791), Vava'u, Tonga, height 64.8 mm. **Figure 5**= *Q. lamarckii* (Deshayes, 1832), Kei Kecil Island, Maluku, Indonesia, height 63 mm.



## **Have a shell collection you would like to donate to The San Diego Shell Club?**

The San Diego Shell Club is interested in your shell collection. As a 501c(3) organization, all donations to our Club may provide a tax write-off. When we receive a donation we provide a letter describing the items that may be used when filing your taxes. While we cannot provide a value, donations of up to \$5,000 do not require a written appraisal. Since tax laws change regularly we recommend that you check with your tax accountant before relying on any information provided here.

We are interested in all types of shells, marine or land and all genera and species, including books on shells as well as items related to shells such as artwork, storage cases and tools. Your donated items will be used to generate income to support the Club's efforts in continuing Public education about shells and conservation of marine life throughout the world. If you would like to donate, please contact David Waller, SDSC Acquisition Chairperson, at [dwaller@dbwipmg.com](mailto:dwaller@dbwipmg.com) to schedule a time to discuss charitable gifting.

## **CLUB NEWS**

### **2021 February - General Meeting**

Canceled due to the COVID19 pandemic.\*

### **2021 March - Holiday Party**

Canceled due to the COVID19 pandemic.\*

### **2021 April General Meeting**

Canceled due to the COVID19 pandemic.\*

\* Accordingly, no general meeting minutes.



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**Seizure and Forfeiture - Part I**  
**United States Fish and Wildlife Service and**  
**The Endangered Species Act of 1973**

David B. Waller

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I have been a shell collector for over 20 years and only recently did the USFWS seize a parcel addressed to me containing two shells, *Conus (eugeniconus) nobilis victor* and *Cypraea Mauritia mauritiana* that I purchased online through shellauction.com from a seller in Indonesia. The two shells including their data slips (Figure 1) were confiscated and a Property Receipt inserted into the empty parcel. The receipt stated that the “parcel was found to contain wildlife/plant products imported in violation of U.S. federal law” and a “Notice of Seizure and Proposed Forfeiture” received a week later stated that the two shells were seized under the “Endangered Species Act, 16 U.S.C. 1538”. Like many of you, I immediately checked the species listed under the Endangered Species Act as well as those listed on the Convention on International Trade in Endangered Species or CITES. There are no Conidae or Cypraeidae species on either listing. For the record, these are not endangered species and no laws were violated as suggested by the USFWS under 16 U.S.C. §1531 *et seq.*

Coll: David Waller

**Conus (eugeniconus) nobilis victor -  
LOVELY COLOR**  
 Broderip, 1842  
 45.80 mm - NTT,Lembata island indonesia  
 quality (f +++) / gem) ---- collected by local divers, at a depth of 5 meters in the sand, on Lembata Island, Indonesia on September 2020

Ex Coll: Firman Syah - 2475024

Coll: David Waller

**Mauritia mauritiana - DWARF & NICE COLOR**  
 Linnaeus, 1758  
 44.72 mm - Lombok Island,Indonesia  
 quality (f +++) / gem) collected by local divers, at a depth of 8-10 meters near the reef.November 2020  
 INDONESIA

Conidae

Ex Coll: Firman Syah - 2474172

Cypraeidae

**Figure 1.** Copies of the data slips that accompanied the shells contained in the parcel.

So the question arises as to how the USFWS could have made this error in identifying the two shells as endangered species? I will attempt to answer this question and others in a three part series regarding this confiscation by the USFWS. In Part I, I discuss the seizure power granted the USFWS by Congress to enforce the Endangered Species Act and contrast this power with the rights granted by the U.S. Constitution. In Part II, I discuss the actions taken by the USFWS as well as my discussion with the inspector and compare those acts with proper procedural protocols that should be exercised when issuing a Notice of Seizure and Proposed Forfeiture. In Part III, I discuss the information obtained from Freedom of Information Act requests submitted to the United States Postal Service and the USFWS, as well as responses from Senators Dianne Feinstein, Alex Padilla and Thomas Carper (Chairperson of the Environment and Public Works Committee, which oversees the USFWS) and other actions that can be considered.

So what is the purpose for Congress in creating an endangered species act? Title 16 U.S.C. §1531 (b) states that “[T]he purposes of this chapter are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes ...”. Key terms of this subsection are underlined and defined under the next subsection; 16 U.S.C §1532. The term “endangered species” means “any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta....”, “threatened species” means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range”, and “conservation” means “to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer necessary”. It is reasonable to assume that individuals in the business of importing or exporting endangered species do so because of an economic benefit and will do what is necessary to conceal their activities. If one accepts this paradigm, then any actions by the USFWS that remove this economic incentive would tend to significantly reduce trade in endangered species. If this is the case, then the question of whether to grant the USFWS the power to seize and inspect parcels suspected of containing endangered species to achieve this goal should be received by a resounding “YES!.” However, inspectors cannot exercise this power with impunity.

Therefore, to effectively and efficiently enforce the Endangered Species Act, the seizure power must be applied in a way so as not to infringe certain rights that we have as citizens of the United States. To better understand where potential conflicts could arise, it is important to look at the chronology of events that took place. On November 25, 2020, I placed winning bids for the two shells; the shells were packaged and sent via parcel post to my address on December 12, 2020. On December 22, 2020, the United States Postal Service, International Mail Facility in San Francisco identified my parcel as being “in violation of and in a manner unlawful of the laws and regulations of the United States”, the parcel was removed from the U.S. Mail and rerouted to the USFWS. After receiving my parcel, the USFWS opened it, removed the shells and data slips and presumably stored them in a holding facility. On January 13, 2021, the USFWS inserted a Property Receipt (Figure 3) into the empty parcel (Figure 2) and forwarded it to me by U.S. Mail.



Figure 2. A photograph of the empty parcel as received.

PROPERTY RECEIPT	
RECEIVED FROM: David Waller	DATE AND TIME OF RECEIPT: 01/13/2021   FILE NUMBER: 2020804616
RECEIVED BY: Wildlife Inspector Catherine Yashuda	LOCATION: USPS ISC SAN FRANCISCO AIR MAIL CENTER
ITEM NO.	DESCRIPTION
1	two (2) shells
<p>This parcel was found to contain wildlife/plant products imported in violation of US federal law &amp; said items (listed above) have been seized by the US Fish &amp; Wildlife Service Office of Law Enforcement.</p> <p>All shipments of wildlife* and protected plants must comply with all relevant laws, both foreign and domestic. Non-compliant shipments are subject to enforcement action including, but not limited to, seizure of the item(s) imported in violation of federal law.</p> <p>A detailed notice of seizure and proposed forfeiture letter explaining the specific violations that occurred with this shipment and your legal options regarding the seizure will be sent to you via certified mail within sixty days of the date of seizure.</p> <p style="text-align: right;">Catherine Yashuda 3/13/21</p> <p><small>*Wildlife means any wild animal, whether alive or dead, including without limitation any bird, mammal, reptile, amphibian, fish, mollusk, crustacean, arachnid, endothermic, or other invertebrate, whether or not bred, hatched, or born in captivity, and including any part, product, egg, or offspring thereof. (Title 50 U.S.C. § 4612)</small></p>	
<p>I hereby certify that the above is a correct and complete inventory of items received/sent by (transferred from) the undersigned officer at the above stated date, time and place, and that the said inventory was made in the presence of:</p> <p><b>OFFICER:</b> <i>CY</i></p> <p><b>WITNESS:</b> <i>M</i></p> <p>I hereby acknowledge receipt of a copy of this inventory and that it is true and complete.</p> <p><b>SIGNATURE:</b> <i>[Signature]</i></p>	

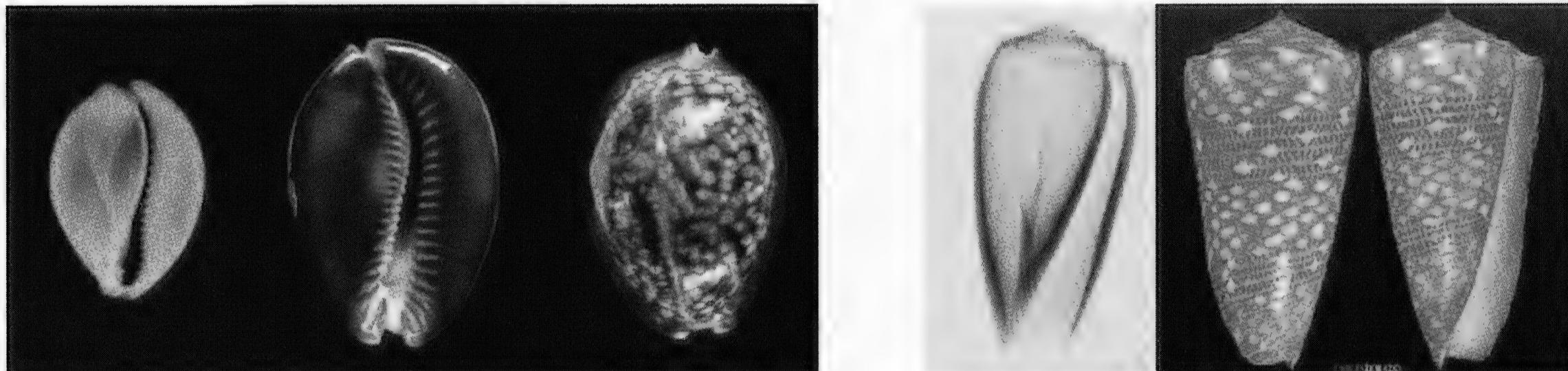
Figure 3. A copy of Property Receipt from Inspector Yashuda of the USFWS.

The USFWS Service Manual, Chapter 445 FW1, Section 1.3 (E) authorizes Service officers to “detain for inspection and inspect any package, crate, or other container, including its contents, and all accompanying documents, upon importation or exportation. . . . Such person . . . may execute and serve any arrest warrant, search warrant, or other warrant or civil or criminal process . . . [and] may search and seize, with or without a warrant, as authorized by law” (16 U.S.C. 1540(e)(3)). However, such inspection requires “probable cause”. Probable cause as defined by USFWS Service Manual, Chapter 445 FW1 Section 1.4 (D) . . . is when an officer can objectively deduce from a set of facts that a person has committed, is committing, or is about to commit a crime. Probable cause for a search is established when facts are sufficiently strong to lead a reasonable, prudent person to believe that evidence of a crime is probably located in the place to be searched. So what right might be infringed by actions conducted under 445 FW1? If conducted without the proper procedures or oversight, then these actions are in direct conflict with the 4<sup>th</sup> Amendment, which provides:

“The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized.”

Let’s look at each action as it occurred and consider what problems could arise under the 4<sup>th</sup> amendment. On December 22, 2020, the United States Postal Service, International Mail Facility in San Francisco identified my parcel as being “in violation of and in a manner unlawful of the laws and

regulations of the United States”, the parcel was removed from the U.S. Mail and rerouted to the USFWS. How was my parcel identified as a parcel of interest? How did the USPS determine that it was in violation of U.S. law? Does the USPS have the right to extract a parcel in the U.S. mail system and reroute it to a location other than to the addressee? To identify a parcel for extraction and rerouting, the USPS must have “probable cause”. Further, they must have probable cause to open the parcel. So how did they determine that the contents were supposedly in violation of U.S. law? It is likely that the USPS used X-ray equipment to scan the contents and seeing images of shells merely forwarded the parcel to the USFWS. However, isn’t scanning the mail an invasion of privacy? In a 1977 case, Ramsey v. U.S., 431 U.S. 606, the court found that a sovereign has the power to inspect inbound mail without a warrant to protect its borders against contraband and to collect duties. The USPS is likely citing this case law to establish their “power to inspect”. If the USPS used X-ray to scan the contents of my parcel they would have seen images similar to those in Figure 4.



**Figure 4.** A= an X-ray image of a Cypraeidae next to an image of *Cypraea Mauritia mauritiana* and B= an X-ray image of a Conidae next to an image of *Conus (eugenconus) nobilis victor*.

Since neither of these X-ray images look anything like X-ray images of any of the species listed under the Endangered Species Act nor present in the CITES listing, how does the USPS establish “probable cause”? Is it possible that Inspectors are not trained to identify these types of images and when seeing something that looks like wildlife or plants they simply send it to the USFWS? Next, after receiving the parcel, the USFWS opened and removed the shells and data slips and presumably stored them in a holding facility. Just as with the USPS, the USFWS must have probable cause to open a parcel. So how did they determine that the contents contained endangered species? It is possible that the USFWS used X-ray equipment to scan the contents or was provided scans taken by the USPS. If they had, it would have been obvious that the contents were not endangered species. In any case, the USFWS chose to open the parcel, and will likely rely on 445 FW1 to establish their “power to inspect”. However, unlike the USPS, the USFWS Inspectors are trained to identify all endangered species covered by the Endangered Species Act as well as those species that are CITES listed. It is clear that an Inspector’s training, along with the data slips, a quick review of each species status by searching the internet and a review of the species listed under the Endangered Species Act and CITES listing was not enough to recognize that there are no Conidae or Cypraeidae species listed as endangered or threatened. So how did the USFWS establish probable cause? Is there sufficient training to enable the inspectors to properly identify endangered species without opening parcels? Does the Agency lack the equipment needed to make accurate determinations?

Finally on January 13, 2021, the USFWS inserted a Property Receipt into the empty parcel and forwarded it to me by U.S. Mail. Shortly after the parcel was delivered, I received a Notice of

Seizure and Proposed Forfeiture from Supervisor Inspector Tome. This document alleged that I was in violation of U.S.C. Title 16, particularly §1538 (d)(1)(A), 1538(e), 3372(b) and 1450(e)(4)(A) and 50 C.F.R. 14.52(c). Each of these code sections hinge on the allegation that I am engaged in “business as an importer or exporter of fish or wildlife”, wherein the wildlife are species covered by the Endangered Species Act. Neither of these documents, nor the Property Receipt nor the Notice of Seizure and Proposed Forfeiture provide any tangible evidence that: the species contained in the parcel were endangered species; the accused is in the business of importing or exporting endangered species; and/or supports probable cause to open the parcel. However, the Notice of Seizure and Proposed Forfeiture does provide the following options for responding to the USFWS: 1. Abandon the property by signing a form of abandonment; 2. Take no action; 3. Forfeit the property by submitting a seized Asset Claim Form; or 4. File a Petition for Remission to stop the forfeiture. So why does only one of these actions allow the accused the ability to recover his/her property? Items 1 and 3 seem questionable and it is highly likely that, by signing either of these forms, the accused admits to violating the Endangered Species Act. To make these options worse, the Notice also states that “forfeiture or abandonment of these seized items may not provide relief from potential liability for civil penalty assessments.” So why would anyone agree to sign these forms? The big concern is that, if you are a collector of sea shells with limited resources, you only really have one option and that is to take no action. I suspect this option is chosen more frequently than most. So what is the benefit to the USFWS in having the accused select this option? In essence, it allows the Agency to act with impunity, reduce their paper work, and increase their stock of non-endangered species that can be later sold to generate revenue. Yes! The USFWS can sell seized property to generate income for the agency (Federal Register Vol. 81 June 17, 2016, section 12.65(a)(4) titled “How does the Service dispose of forfeited or abandoned property?). This seems like a significant conflict of interest.

In concluding Part 1 of this series, it is my belief that unless the USPS can demonstrate probable cause to investigate the parcel, they likely violated the 4<sup>th</sup> Amendment. Without probable cause they cannot open or scan the parcel with X-ray radiation. Since they were able to determine that the parcel contained something of interest to the USFWS they likely scanned the parcel. By rerouting the parcel to the USFWS, they interfered with the U.S. mail and should be subject to 18 U.S.C. §1701, which states: “Whoever knowingly and willfully obstructs or retards the passage of the mail, or any carrier or conveyance carrying the mail, shall be fined under this title or imprisoned not more than six months, or both.”

Likewise, unless the USFWS can demonstrate probable cause for opening the parcel, they likely violated the 4<sup>th</sup> Amendment. Without probable cause the property contained within was confiscated illegally. If so, the USFWS took personal property without permission or consent with the intent to deprive the owner of it. Could the USFWS then be subject to criminal prosecution for theft?

It appears that one of the crucial problems with the current process is lack of transparency. Claims made by the USFWS should be fully supported with clear and convincing evidence before any action is taken. The USFWS Office of Law Enforcement understands evidentiary procedure and should not authorize any action without properly obtained legal evidence to support their accusations. Further, that supporting evidence should be provided in The Notice of Seizure and Proposed Forfeiture.

## My Most Memorable Find as a Shell Seeker

Paul Kanner

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I've been searching for shells since I was a little boy. Someone has to find them. Why not I?

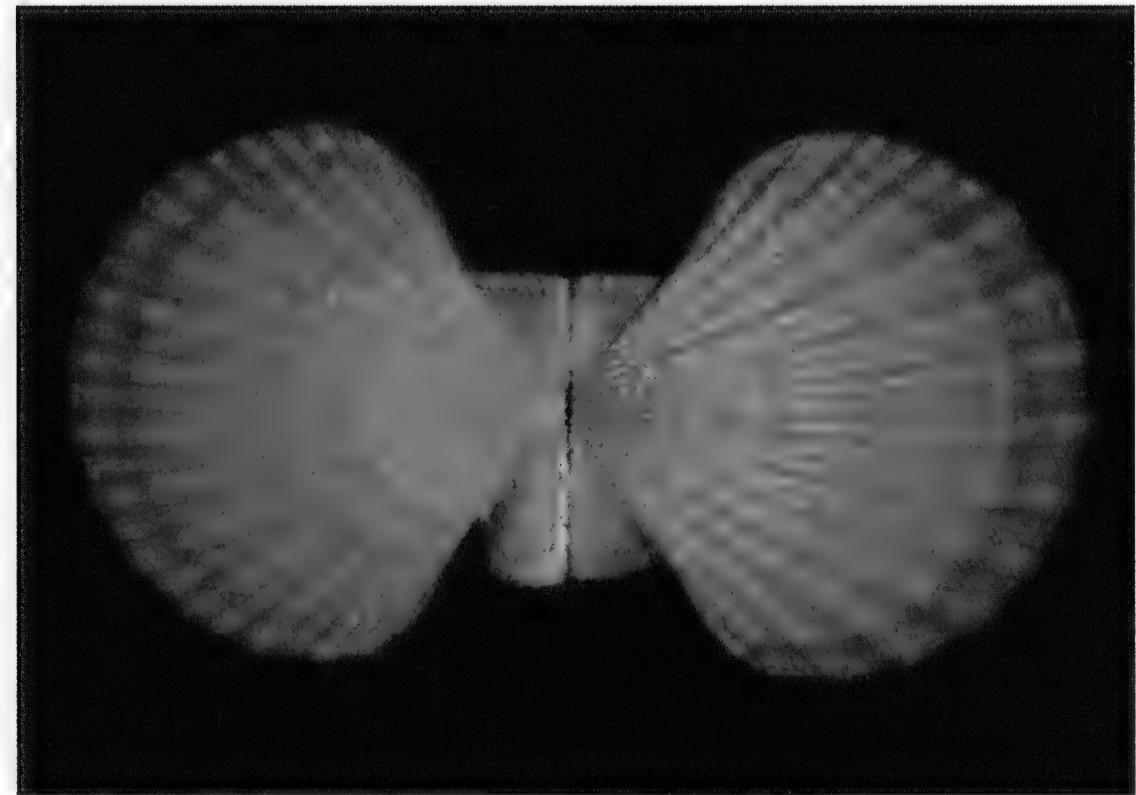
In March of 1987 I was invited to crew on a private yacht that had a permit from the Ecuadorian government to cruise and explore the Galapagos Islands. I was the dive master for the guests and engineer. We took a naturalist from the government aboard to make sure we observed all the conservation protocol. Back then they were not as concerned about the sea as they were the land. So we were able to dive pretty much without restriction. What an opportunity for a shell seeker!

We anchored in Tagus Cove on Isabela Island. A couple of the guests wanted to make a dive. So we loaded up our little Zodiac inflatable skiff. We motored north about a half mile to a spot that looked good for diving. It was an El Niño year so the water was warm and clear. The dive was to about 90 feet deep to where the drop-off reached the sand at the base of the island. It was a pleasant dive with lots to explore in the holes and ledges of the island wall. Time was up. Time to surface safely. At about 45 feet up as I was escorting the divers to the surface, I happen to look back down at the bottom and saw a faint fan pattern in the sand next to the edge of the drop-off. Could it be?. I signaled the divers to continue to surface and swam back down to investigate. Going back down is not a smart thing to do in diving. When I reached the bottom I took a swipe at the outline in the sand and gave a tug and there it was - a large *Nodipecten magnificus* that had been attached to the rocks by byssus threads.

Attached images of the shell right after collecting and after cleaning for display.



**Figure 1.** Fresh collected *Nodipecten magnificus* next to Paul Kanner's hand for reference



**Figure 2.** Cleaned specimen of *Nodipecten magnificus*.

## Smaller California Record Size Shells - Part Two

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**In Review.** The Conchological Club of Southern California (“CCSC”), formed in 1902, maintained a list of record size shells from about 1950 to 1987, titled the List of Champions of the Lost Operculum Club (LOC). In 1997, the LOC records and World Size Records of Wagner and Abbott were incorporated into the new Registry of World Record Size Shells (WRS). In 2008, control of the WRS passed to new hands far from California. Rather than grandfather older established records, a new rule allowed unphotographed listings to be replaced by smaller photographed specimens, assuming that photos verified proper identification and measurement. The rule initiated a scramble for easily obtained WRS listings as photographs, not shell size, which became a key factor in record selection. Many former LOC records have been replaced by smaller shells and some have been deleted without a replacement through 2016, a process perhaps now completed. The former records of Wagner and Abbott and other unphotographed 2008 WRS records have experienced a similar fate.

The replaced and deleted records, that had frequently stood for decades, are often held by deceased or elderly collectors are now required to reestablish their records. Museums that hold replaced or deleted records may be reluctant to expend the time required to again register their shells and some collectors may not realize their records were given an expiration date. Few recall a record once it's replaced. Lest we forget, the following list, with exceptions, provides the history of some former LOC records that have been replaced by smaller WRS listings or deleted, limited to species found off California. Since the final 2018 WRS print edition was expensive and the website charges fees, the listings in the 2016 WRS edition will be used for comparison.

1. *Acanthinucella spirata* (Blainville, 1832). The 1980 LOC through 2001 WRS record was 41.5 mm, collected Newport Beach, CA, 1965, by Jack Brookshire. Jack (1923-1998), Editor of the Molluscan Digest, 1973-1976, was a Santa Barbara Malacological Society member. The 2005 through at least 2008 WRS record was 41.9 mm, collected Long Beach, CA, 1963, held by W.D. Schroeder. The 2016 WRS listing was 32.49 mm. My largest *spirata* is 35 mm.
2. *Acmaea mitra* Rathke, 1833. The 1980 LOC through at least 2008 WRS record was 50.9 mm, collected Mukkaw Bay, WA 1966, by Bob Howley. Robert T. Howley (1936-2005), a CCSC member, collected and studied the shells of The West Coast of North America for forty years. He wrote A Range Extension of *Nassarius miser* (Dall, 1908) in 1983 for The Veliger, 26(2). The 2016 WRS *mitra* listing was 29.05 mm, collected Canada, with an albinistic form at 45.32 mm. James McLean, 1978, described the White-Cap Limpet as white.
3. *Anomia macrochisma* (Deshayes, 1839). The 1980 LOC as *Pododesmus cepio*, through at least 2008 WRS record was 128.4 mm, collected Port San Luis, CA 1967, by Jack Brookshire. My largest is 121.9 mm. The 2016 WRS listing as *Pododesmus macrochisma*, was 86.51 mm.
4. *Calinaticina oldroydii* (Dall, 1897). The 1987 LOC through at least 2008 WRS record was 80.7 mm, collected by otter trawl off Palos Verdes, CA, 1979, by Bob Howley. The 2016 WRS listing was 42.13 mm. Tucker Abbott, 1974, noted the size to three inches or 75 mm.
5. *Calliostoma aequisculptum* Carpenter, 1865. The 1980 LOC through at least 2008 WRS record was 25 mm, collected Mexico, 1968, by McLean and Oringer, held by the LACM. The eminent James H. McLean (1936-2016), an authority on Eastern Pacific gastropods, assembled much of the LACM's mollusk collection. The 2016 WTS listing was 19.38 mm.

6. ***Calliostoma ligatum*** (Gould, 1849). The 1980 LOC through at least 2008 WRS record was 32.7 mm, collected Tacoma Narrows, WA, 1966, by Bob Howley, who had eight 1987 LOC records. The 2016 WRS listing was 26.5 mm. My largest are 26.7 and 27 mm.
7. ***Calliostoma mcleani*** Shasky and Campbell, 1964. The 1980 LOC through at least 2008 WRS record was 14.6 mm, collected Mexico, 1972, by Jim Cordy. Jim (1932-2018), a diver, had nine 1987 LOC records, including three *Calliostoma* listings. The 2016 WRS listing was 11.64 mm, collected Mexico.
8. ***Calliostoma turbinum*** Dall, 1896. The 1980 LOC through at least 2005 WRS record, no listing 2008, was 20.3 mm, collected Santa Cruz Island, CA, 1940, from the A. Hancock Collection, held by the LACM. George "Allan" Hancock (1875-1965), funded oceanographic research aboard his ships, including the Velero III. Extended voyages were referred to as Hancock Expeditions. The 2016 WRS listing was 13.2 mm.
9. ***Chama arcana*** Bernard, 1976. The 1980 LOC through 2001 WRS record was 79.4 mm, collected Laguna Beach, CA, 1978, by Roger Evans. The 2005 through at least 2008 WRS record was 86.1 mm, held by Walter D. Schroeder. The 2016 WRS listing was 72.21 mm.
10. ***Crepidula glottidiarum*** Dall, 1905. The 1987 LOC record was 29.4 mm, collected Redondo Beach, CA, 1980, by Roger Evans. The species, accepted by WoRMS, lives on the valves of the brachiopod *Glottidia albida*. There has been no WRS listing for this species through 2016.
11. ***Crepidula nummaria*** Gould, 1846. The 1980 LOC through at least 2008 WRS record was 56.3 mm, collected Port San Luis, CA, 1967, by Jack Brookshire, who had four 1987 LOC records. The 2016 WRS listing was 27.11 mm.
12. ***Crepidula perforans*** (Valenciennes, 1846). The 1980 LOC through 1999 WRS record was 45.5 mm, collected in the outer lip of a *Melongina patula*, Guaymas, Mexico, 1968, from R. French, held by Bert Draper 1987, of which about 67 were self-collected. Collectors often gave Bert their minute shells and he would credit those collectors in the LOC listings. The 2001 through at least 2008 WRS record was the Draper specimen now held by the LACM. The 2016 WRS listing was 28.59 mm. My largest are 40.4 and 41.4 mm.
13. ***Crepipatella lingulata*** (Gould, 1846). The 1980 LOC through at least 2008 WRS record was 26.3 mm, collected San Pedro, CA, 1979, by Roger Evans. Roger, a diver, was a CCSC member, and had 97 LOC records in 1987. The 2016 WRS listing was 20.3 mm.
14. ***Donax gouldii*** Dall, 1921. The 1980 LOC through 1999 WRS record was 31.5 mm, collected Pismo Beach, CA, 1960, by the notable John E. Fitch. John (1918-1982) was a Research Director at the California Dept. of Fish and Game, where he wrote Common Marine Bivalves of California, 1953. The 2001 through at least 2008 WRS record was a prodigious 38.8 mm, collected Baja CA, held by Bill and Nancy Schneider. William (1930-2011) and Nancy were San Diego Shell Club members. The 2016 WRS *gouldii* listing was 23.24 mm, collected Mexico. My largest is 27.4 mm.
15. ***Engina strongi*** Pilsbry and Lowe, 1932. The 1980 LOC through at least 2008 WRS record was 20.8 mm, collected Catalina Island, CA, 1941, from the A. Hancock collection, held by the LACM. The 2016 WRS listing was 12.48 mm.
16. ***Epitonium minuticostatum*** (DeBoury, 1912). The 1987 LOC had a fossil listing as *Asperiscala m.*, collected Playa del Rey, CA, 1979, by Bert Draper at 23 mm. Bert self-collected recent and fossil shells. Keen, 1971, and DuShane, 1979, recorded the range from California to the Galapagos Islands, reaching 35 mm. Dushane recorded as a fossil only in Southern California. I've collected seven apparently recent specimens off Redondo Beach, CA, 1981-82, 13.5 to 18.5 mm. There was no WRS listing through at least 2008. The 2016 WRS listing was 11.97 mm, collected Panama.
17. ***Globivenus fordii*** (Yates, 1890). The 1980 LOC as *Ventricolaria f.*, through at least 2008 WRS record was 75.2 mm, collected Palos Verdes, CA, no date, by Joe V. Robinson. The 2016 WRS had no listing for this species under Veneridae.
18. ***Haliotus sorenseni*** Bartsch, 1940. The 1980 LOC through at least 2008 WRS record was 227 mm, collected diving at 34 meters off Catalina Island, CA, 1978, by Gary Kimes. Abalone records are competitive and highly prized. The 2016 WRS listing was 226.1 mm.
19. ***Hespererato columbella*** (Menke, 1847). The 1980 LOC through 1999 WRS record was 8.6 mm, collected Cabrillo Beach, San Pedro, CA, 1963, by Bert Draper. The 2001 through 2005 WRS record was the Draper specimen, now held by the LACM. The 2008 WRS record was a remarkable 11 mm, held by Walter D. Shroeder, collected 1938. Walter purchased collections and examined the specimens for potential record size shells. His

considerable efforts did much to improve the record quality of the 1987 LOC, as noted by Bert Draper, and later the WRS. Walker had about 300 LOC records in 1987 and 830, apparently unphotographed, 2008 WRS records. In 2016, he had 338 remaining records. The 2016 WRS *columbella* listing was 6.04 mm. My largest is 7.2 mm. James McLean, 1978, noted the size at 5-7 mm.

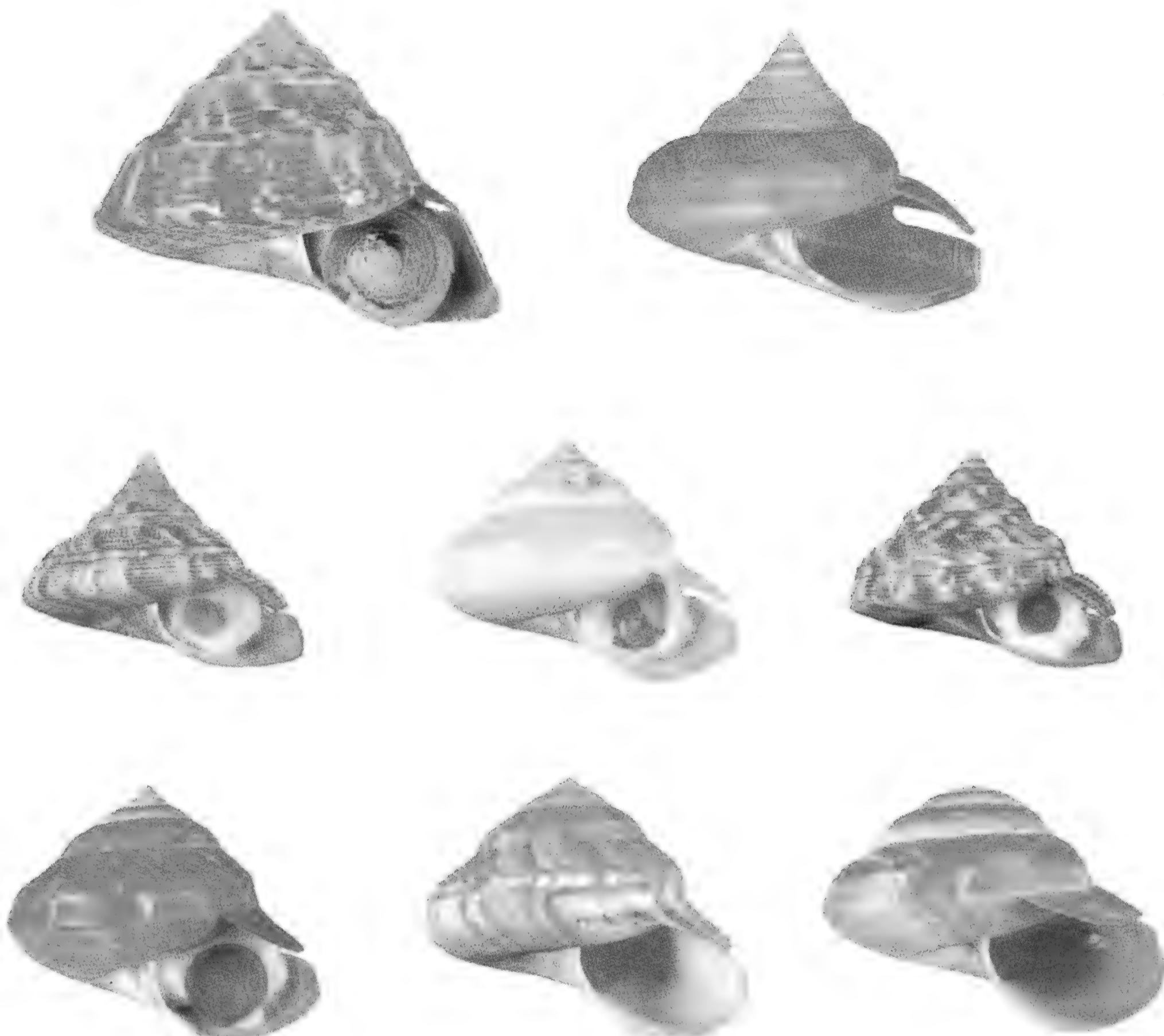
20. *Kellia laperousii* (Deshayes, 1839). The 1980 LOC through at least 2008 WRS record was 33.5 mm, collected Monterey, CA, no date, by the notable Emery P. Chace. Emery (1882-1980) was curator of Mollusca at the San Diego Society of Natural History, 1954-1967, and a prolific collector. The 2016 WRS had no listing for this species under Kelliidae.
21. *Lottia insessa* (Hinds, 1842). The 1980 LOC as *Notoacmea i.*, through at least 2008 WRS record as *Acmaea i.*, was 23.1 mm, collected Pillar Point, San Mateo County, CA, 1920, by Emery P. Chace. The 2016 WRS listing was 10.1 mm. My largest *insessa* is 19.1 mm. James McLean, 1978, noted the size at 14-19 mm.
22. *Lottia limatula* (Carpenter, 1864). The 1980 LOC through at least 2008 WRS record was 52.6 mm, collected Palos Verdes, CA, 1968, by Charles L. Powell. Charles (1923-1995), was a CCSC member. The 2016 WRS listing was 31.24 mm. McLean noted the size at 30-45 mm.
23. *Lottia scabra* (Gould, 1846). The 1980 LOC as *Collisella s.*, through 2001 WRS record was 35.4 mm, collected Pillar Point, CA, 1920, by Emery P. Chace. The 2005 through at least 2008 WRS record was 38.4 mm, collected Big Sur, CA, 1982, by Paul Patchick. Paul wrote Beachcombing Along Monterey Bay, Hawaiian Shell News, May 1987, and other articles. The 2016 WRS listing was 30.84 mm.
24. *Lucinisca nuttalli* (Conrad, 1837). The 1987 LOC through at least 2016 WRS record was collected Palos Verdes, CA, 1983, by Roger Evans. Listed at 30.4 mm, as measured by Bert Draper, through at least 2008, but by 2016 recorded at 46.5 mm, in error. A remeasure discovered the specimen had indeed grown to 30.5 mm, not 46.5.
25. *Macrarene cookeana* (Dall, 1918). The 1987 LOC record was 34.75 mm, while the same specimen in the 1997 through at least 2008 WRS was listed as 34.7 mm, collected by Joe V. Robinson diving at 40 meters off San Clemente Island, CA, 1975. The 2016 WRS listing was 29.84 mm.
26. *Megastraea undosa* (Wood, 1828). The 1980 LOC through at least 2008 WRS record was 155 mm, collected Santa Cruz Island, CA, 1978, by Howard Martin. Howard was on the California State Fish and Game commission. The 2016 WRS listing was 145.4 mm.
27. *Megasurcula carpentariana* (Gabb, 1865). The 1980 LOC through at least 2008 WRS record was 105.6 mm, collected San Pedro, CA, 1961, by Charles L. Powell. The 2016 WRS listing was 105.2 mm.
28. *Melanella micans* (Carpenter, 1864). The 1987 LOC as *Balcis m.*, through at least 2008 WRS record was 12.2 mm, collected outside a mantis shrimp hole off Palos Verdes, CA, 1979, by Roger Evans. The 2016 WRS listing was 9.26 mm.
29. *Mitromorpha intermedia* (Arnold, 1903). The 1980 LOC as *Cymakra i.*, through at least 2008 WRS record was 11.4 mm, collected Torrance Beach, CA, 1979, by Paul Stillians. Paul, a diver, had nine 1987 LOC records. The 2016 WRS had no listing for this species under Turridae.
30. *Mytilimeria nuttalli* Conrad, 1837. The 1980 LOC through at least 2008 WRS record was 46.5 mm, collected Monterey, CA, 1979, by Roger Evans. The 2016 WRS had no listing for this species under Lyoniidae.
31. *Mytilus edulis* Linnaeus, 1758. The 1980 LOC through 2001 WRS record was 133.2 mm, collected Sea Beach, CA, 1957, by Katherine Shuman, who had nine 1987 LOC records and was a CCSC and Long Beach Shell Club member. The 2005 through at least 2008 WRS record was 177 mm, collected California, 1992, by Paul Patchick. The 2016 WRS had no listing for *M. edulis*; *M. edulis edulis* was 62.3 mm.
32. *Nassarius mendicus* (Gould, 1849). The 1980 LOC through at least 2008 WRS record was 24 mm, collected Monterey, CA, 1979, by Roger Evans. Splitters would regard the above specimen as a *mendicus mendicus*. The 2016 WRS had no listing for *N. mendicus*; *N. mendicus mendicus* was 20.47 mm and *N. mendicus cooperi* was 22.3 mm.
33. *Nassarius tegula* (Reeve, 1853). The 1980 LOC through at least 2008 WRS record was 22.9 mm, collected Balboa Island, WA, 1959, by Charles L. Powell, who had five 1987 LOC records. Charles' son, Charles II, had one fossil record in 1987. The 2016 WRS *tegula* listing was 17 mm.
34. *Nucella lamellosa* (Gmelin, 1792). The 1980 LOC through at least 2008 WRS record was 91.9 mm collected Alaska, 1970, by Rae Baxter (1929-1991). Rae was on the Alaska Fish and Game Commission and had 25 LOC

records in 1987. He also named some shell species and had five named after him. The 2016 WRS had no listing for *N. lamellosa*, *N. lamellosa lamellosa* was 68.38 mm with an albinistic form at 81.7 mm.

35. *Opalia spongiosa* Carpenter, 1866. The 1980 LOC through at least 2008 WRS record was 12.8 mm, collected Mexico, 1938, from the Willet Collection, held by the LACM. George Willet (1879-1945), named about forty shell species and had ten named after him. The 2016 WRS listing was 7.36 mm. I have a 9.15 mm specimen collected Palos Verdes, CA, 1979.
36. *Opalia wroblewskyi* (Morch, 1875). The 1980 LOC through at least 2008 WRS record as *O. borealis*, was 59.8 mm, collected Alaska, 1960, by Rae Baxter. This is a large *Opalia* with several synonyms. The 2016 WRS listing was 29.9 mm and a synonymous *O. borealis chacei* was listed at 16 mm. I note the 2016 WRS listing for *Opalia montereyensis* (Dall, 1907), that may be confused with *wroblewskyi*, at a colossal 42.1 mm. The *montereyensis*, per Helen DuShane and James McLean is a small species to 16 mm.
37. *Petricola carditoides* (Conrad, 1837). The 1980 LOC through 2001 WRS record was 42.5 mm, collected Palos Verdes, CA, 1978, by Roger Evans. The 2005 through at least 2008 WRS record was 50.5 mm by Paul Patchick. Paul had 77 records, including some very respectable California bivalve records in the 2008 WRS edition. He had twelve remaining records in 2016. The 2016 WRS *carditoides* listing was 26.7 mm. McLean noted the size at 20-40 mm.
38. *Pomaulax gibberosus* (Dillwyn, 1817). The 1980 LOC through at least 2008 WRS record was 79.7 mm, collected Vancouver Island, Canada, 1966, from the S. Thorp Collection, held by the LACM. The 2016 WRS listing was 65.86 mm.
39. *Saxidomus nuttalli* Conrad, 1837. The 1980 LOC through at least 2008 WRS record was 148 mm, collected Morro Bay, CA, 1928, by Emery P. Chace. The 2016 WRS had no listing for this species under *Veneridae*.
40. *Turcica Caffea* (Gabb, 1865). The 1987 LOC record was 32.7 mm, collected Santa Barbara Co, CA, 1975, by Jim Cordy. The 1997 through at least 2008 WRS record was 39.1 mm, collected CA, 1995, held by the Santa Barbara Museum of Natural History. The 2016 WRS listing was 22.9 mm under *Chilodontidae*.
41. *Volvulella cylindrica* (Carpenter, 1864). There was no listing for this species in the LOC through at least 2008 WRS under *Retusidae*. The 2016 WRS listing was 3.76 mm, collected Panama. Keen, 1971, #2250, recorded the range north to Southern California, reaching 6 mm. I collected six off Palos Verdes, CA, 1979, 6.5 to 9 mm.
42. *Zirfaea pilsbryi* Lowe, 1931. The 1980 LOC record was 143 mm, collected Tomales Bay, CA, 1967, by Glenn H. Totten. Glenn was on the California State Fish and Game Commission and had five 1987 LOC records. The 1987 LOC record was 143.8 mm, collected Redondo Beach, CA, 1980, by Roger Evans. The 1997 through at least 2008 WRS listing was the resurrected 143 mm Totten specimen. The 2016 WRS *pilsbryi* listing was 92.91 mm. McLean noted the size at 60-120 mm.

The defining characteristic of a record shell is its size and the response to a credible record is often, “Wow!” When the response is, “I have several larger than that,” something is amiss. Some of the 2016 WRS photo replacement listings (and new species listings) were so surprisingly small, they may have since been replaced by larger specimens. That said, the apparent lack of applied size standards by the WRS is troubling.

I became acquainted with Bert Draper’s record process and philosophy during about twenty LOC shell measuring sessions, at Bert’s home, from 1977 to 1985. Bert often spoke of the contributions of deceased collectors, who were noted by an asterisk at the back of LOC editions. He wanted new species listings to measure near the upper size range found in references, to ensure that they were reliable examples of record size shells. No listing was preferable to an undersized fill-in, that could mislead collectors and researchers. Bert’s approach to record quality still has merit. Drawn by the appeal of tropical species, the subdued qualities of California’s shells are often overlooked by collectors in distant locals. I await the day when a California based organization, such as a museum or shell club, reclaims the documentation of California’s record size shells, providing the familiar hand and oversight they deserve.



*E. adansonianus adansonianus* (Crosse & Fischer, 1861), Bahamas, 106.1 mm. *B. poppei* (Anseeuw, 2003), Tonga Islands, 58.8 mm. *P. amabilis f. maureti* Harasewych & Askew, 1993, USA, 42 mm. *B. tangana* (Bouchet & Métivier, 1982), New Zealand, 55.9 mm. *P. quoyanus* (Fischer & Bernardi, 1856), Curaçao, 50.7 mm. *B. philippei* Poppe, Anseeuw & Goto, 2006, Philippines, 65.1 mm. *B. chalcostomensis* Askew, 1987, Martinique, 77.3 mm. *B. midas* (Bayer, 1965), Bahamas, 82.7 mm.

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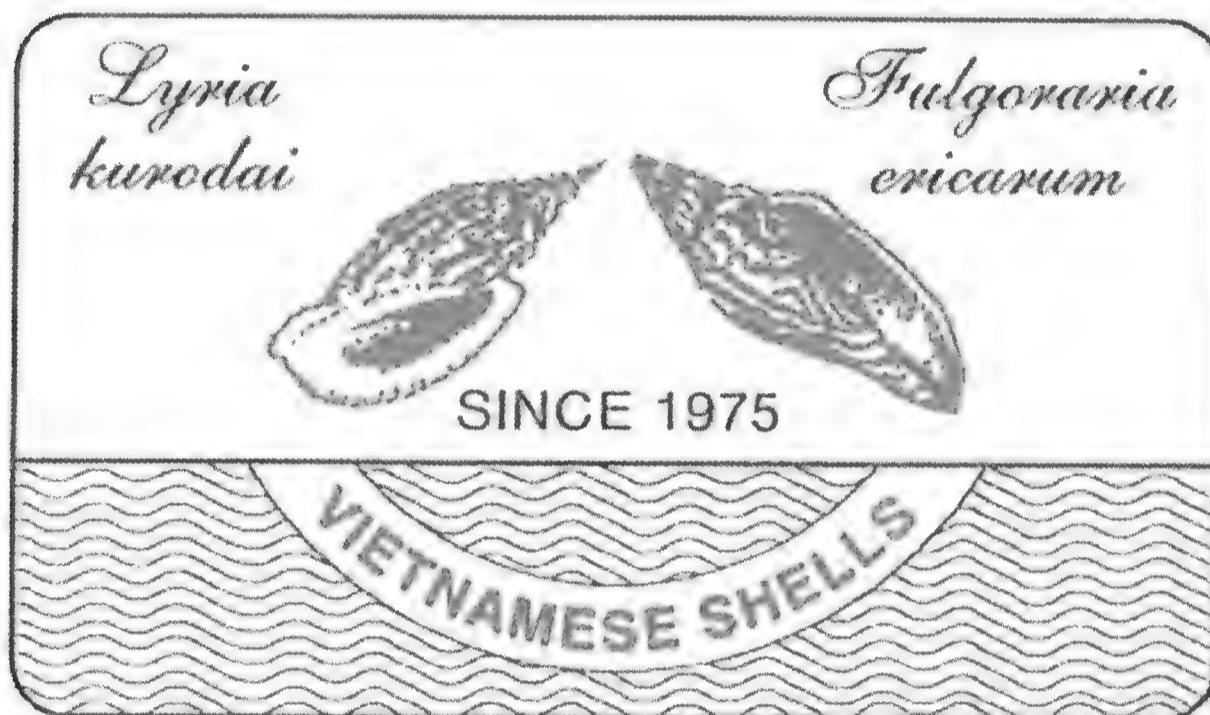
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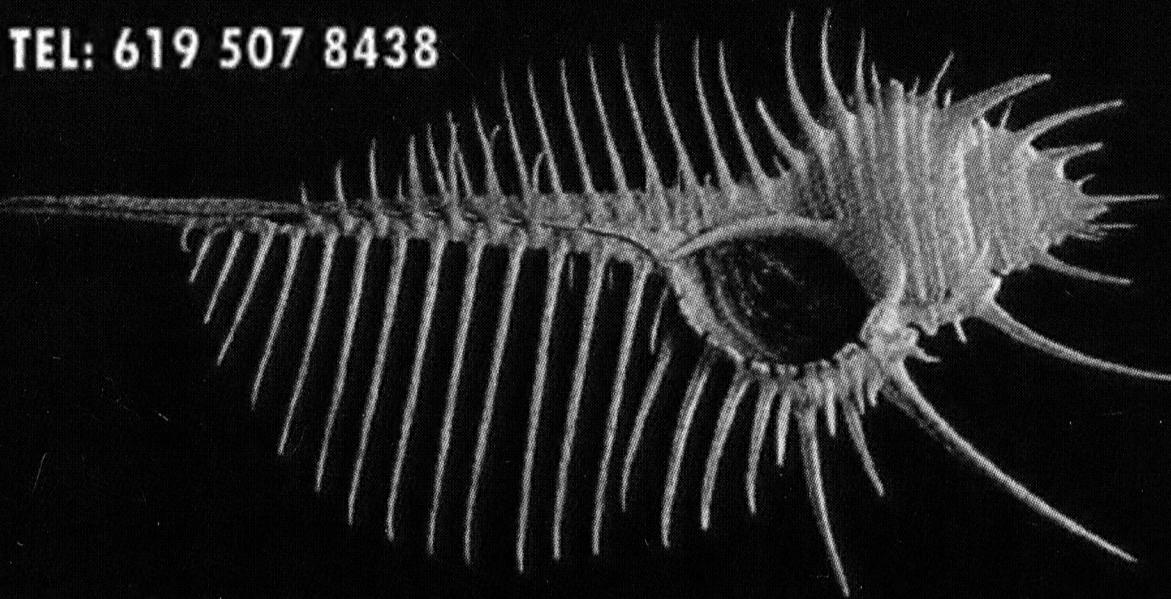
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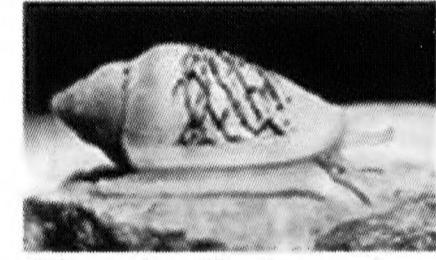
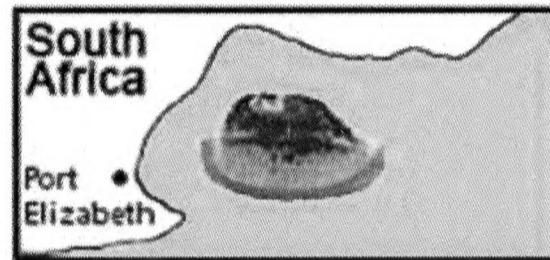
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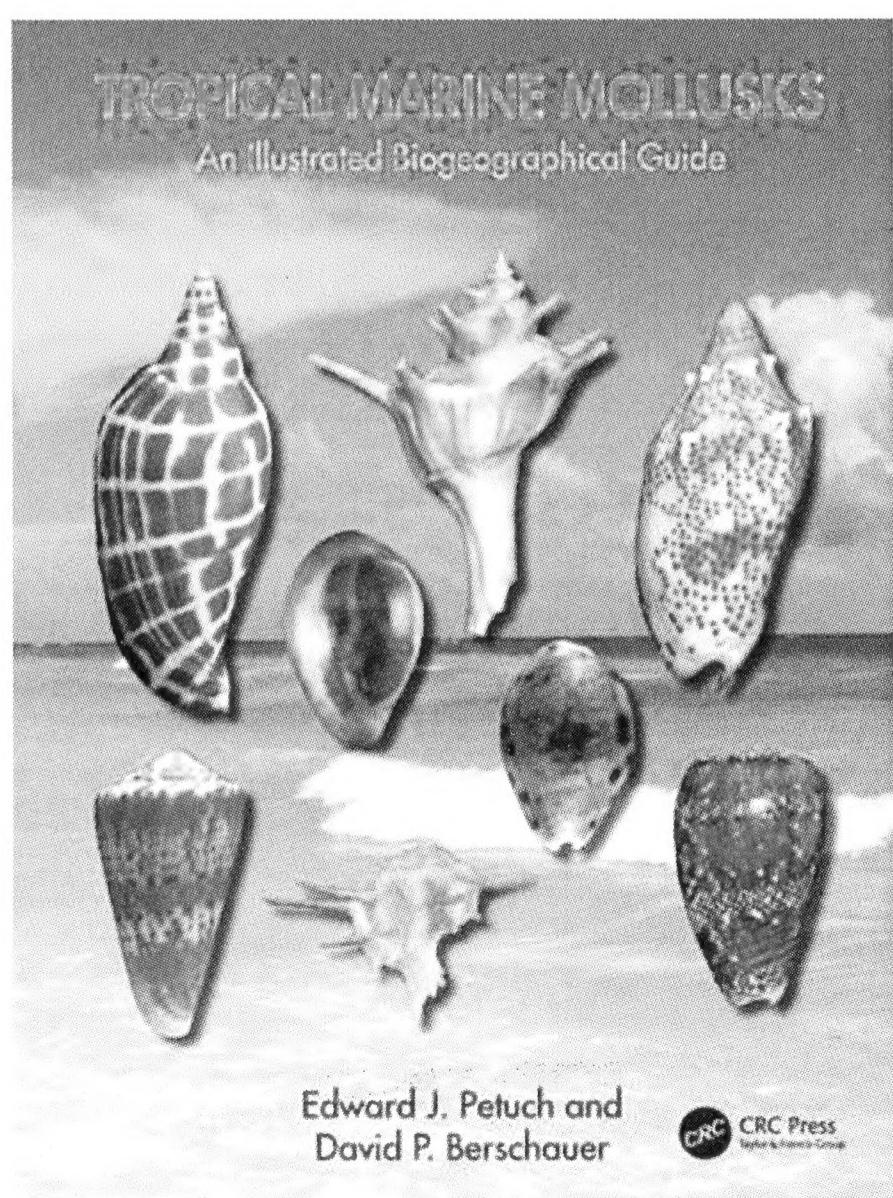
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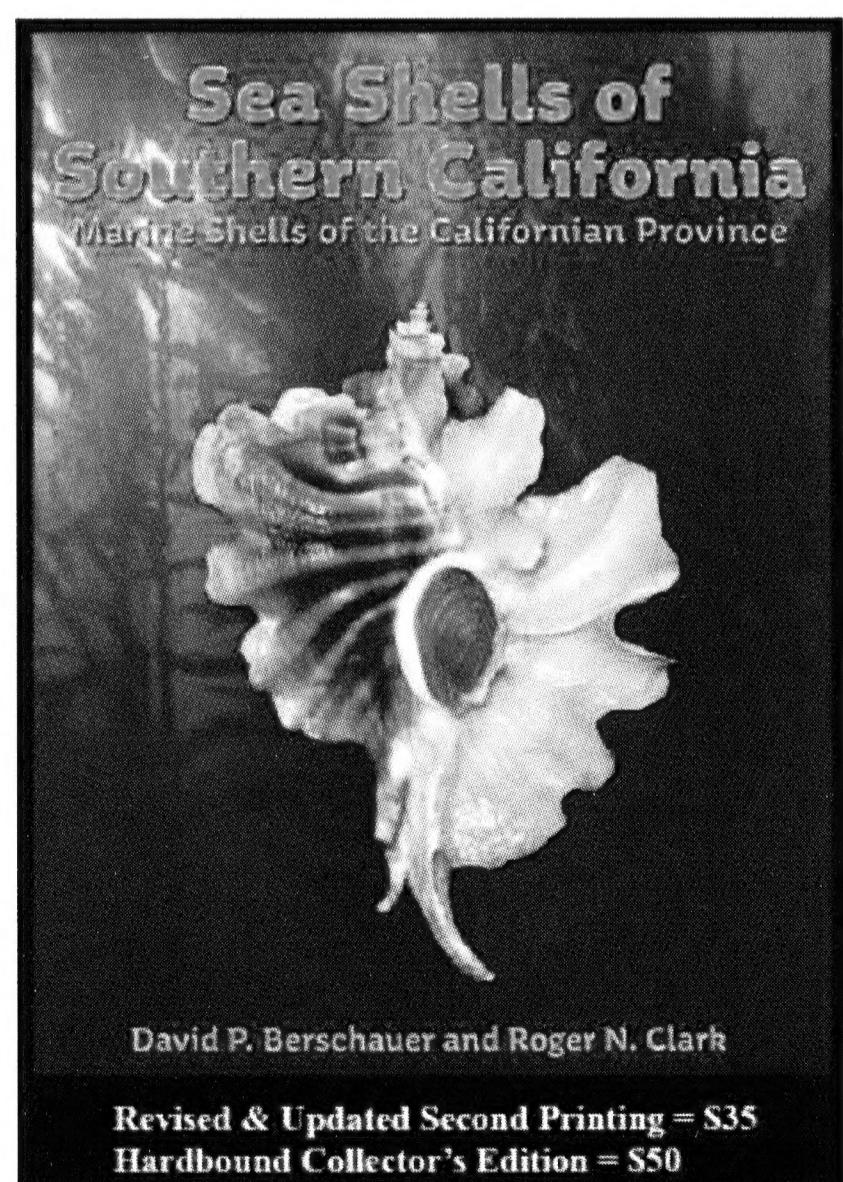


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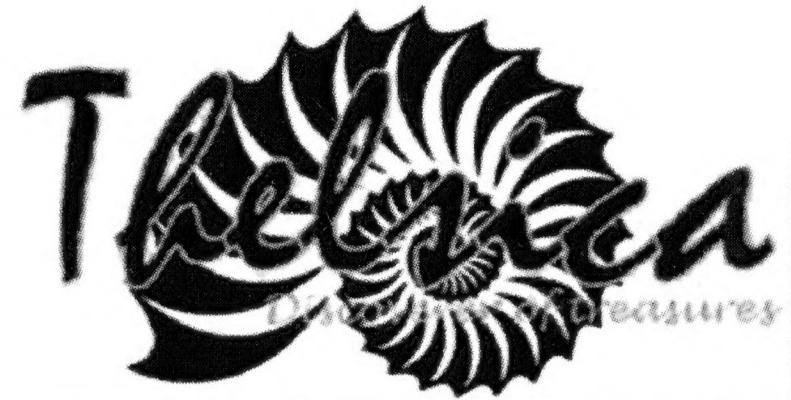
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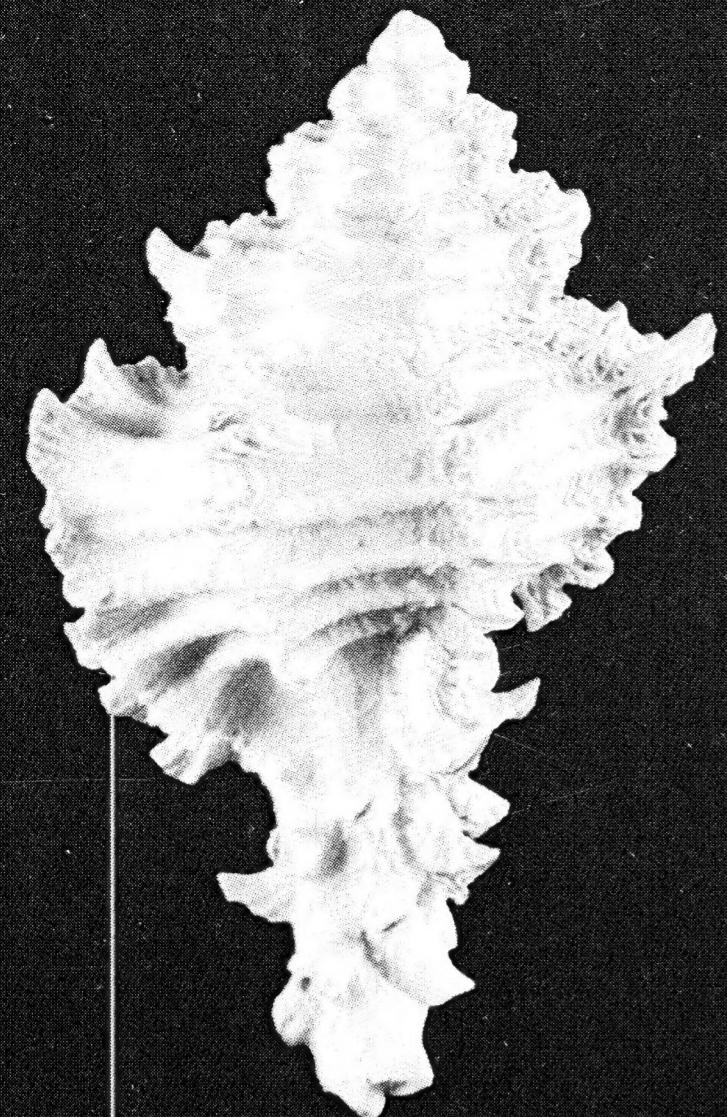
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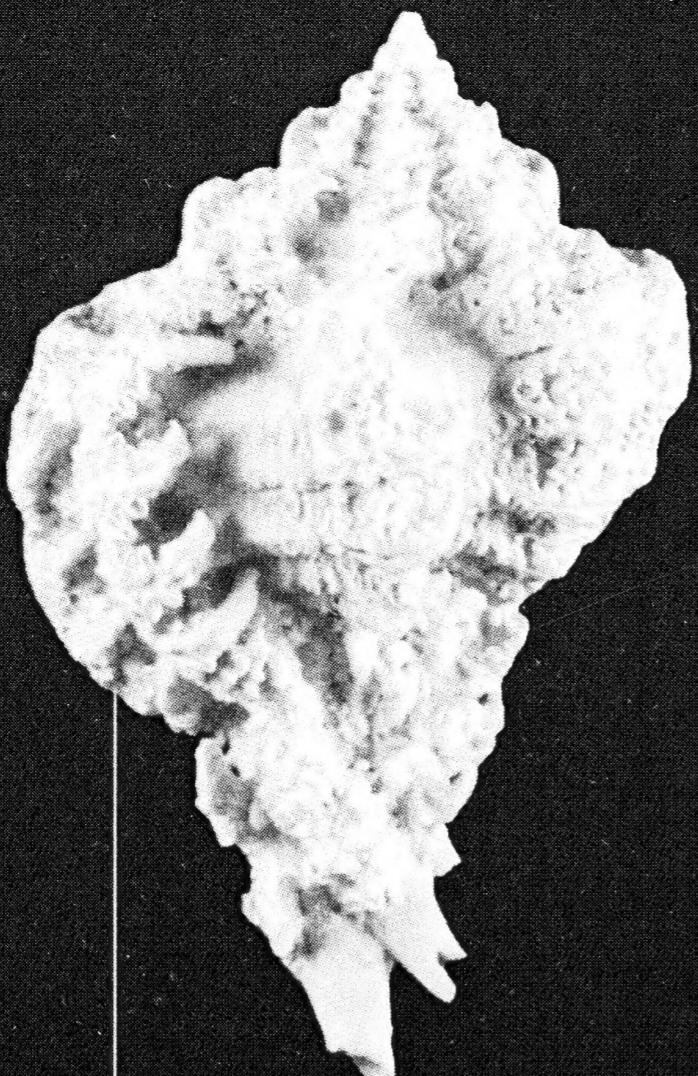
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*Murexiella macginityi*  
M. Smith, 1938

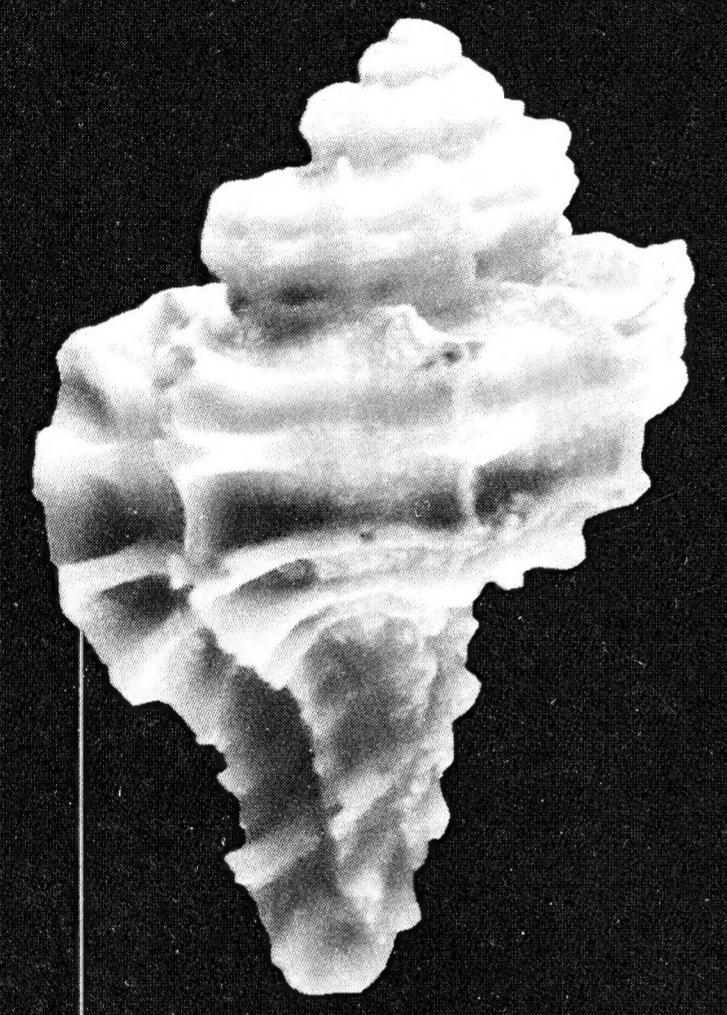


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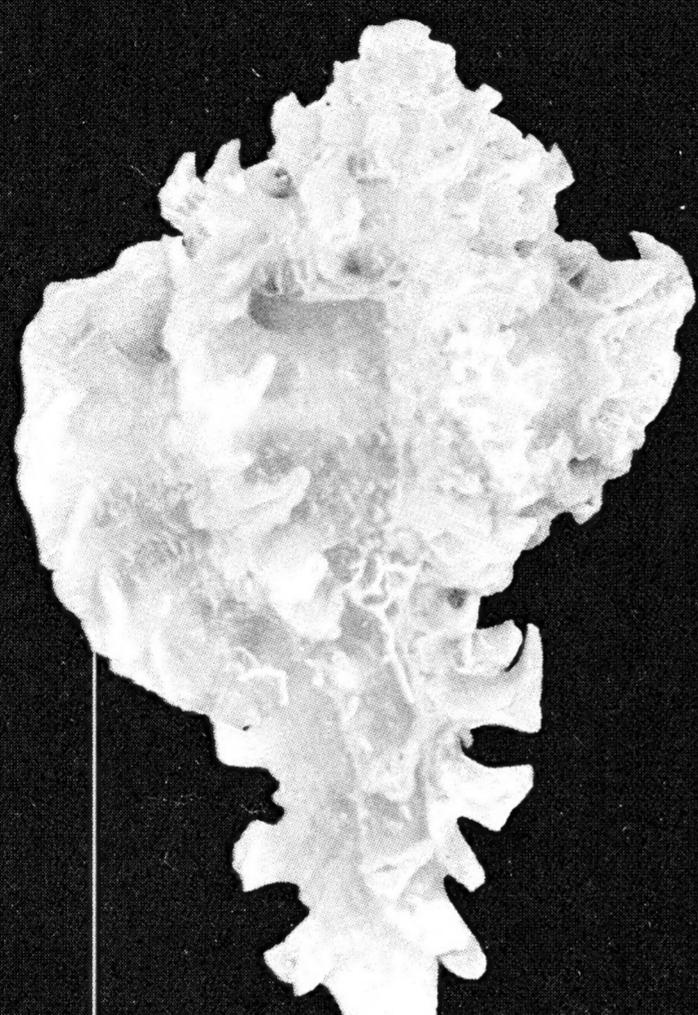


*Murexiella fecetae*  
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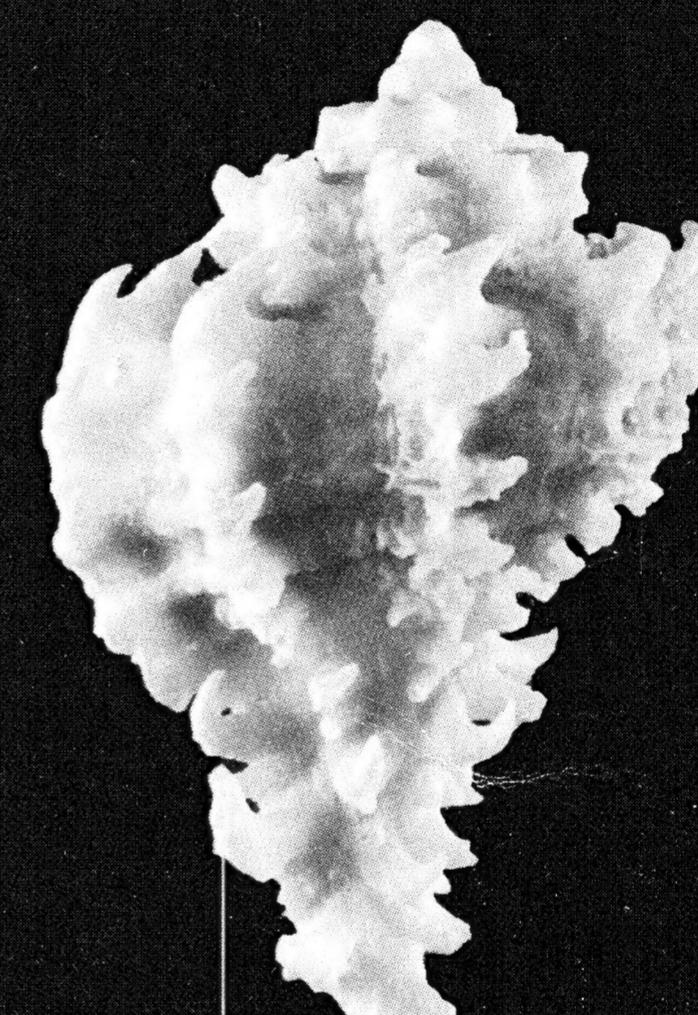
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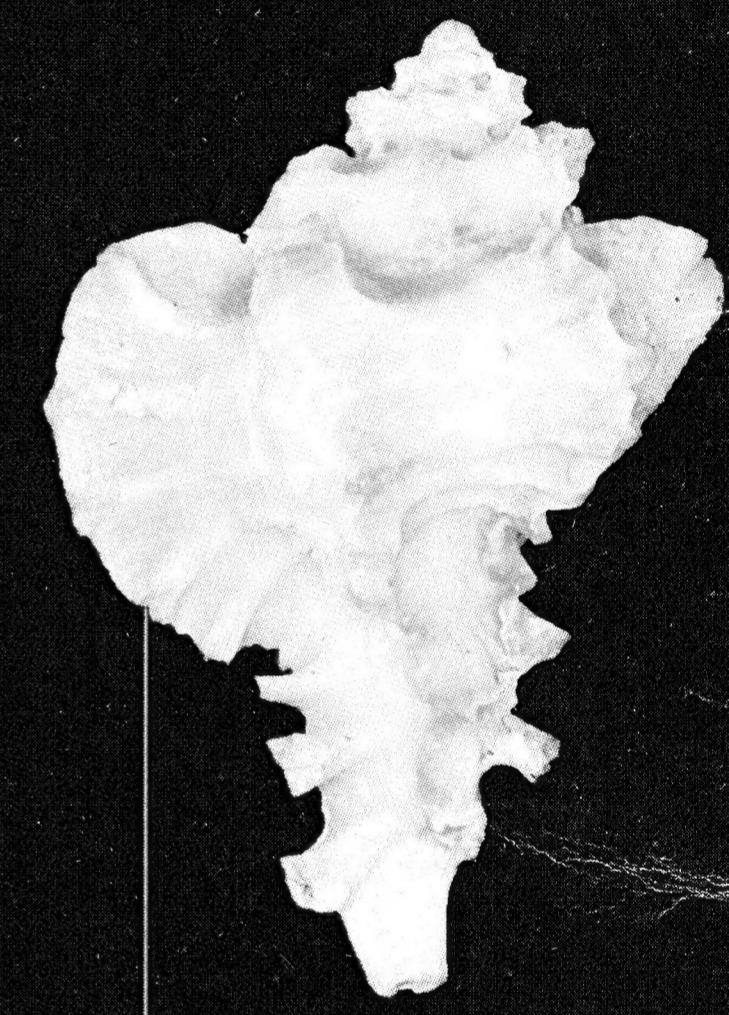
*Murexiella deynzerorum*  
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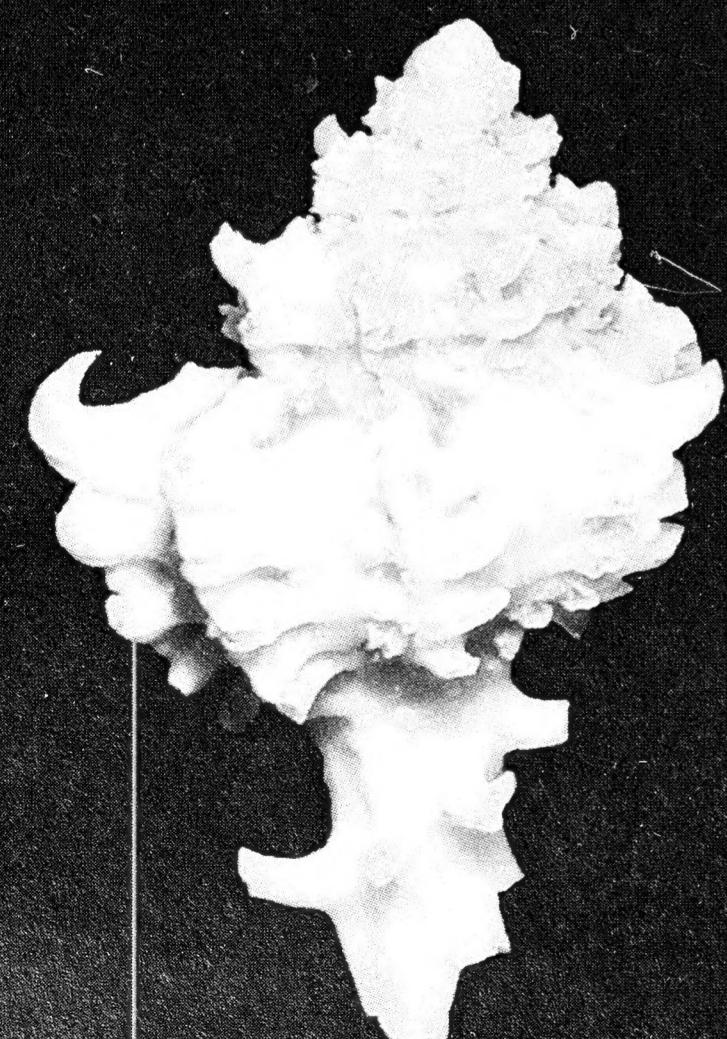
*Murexiella edwardpauli*  
Petuch, 1990



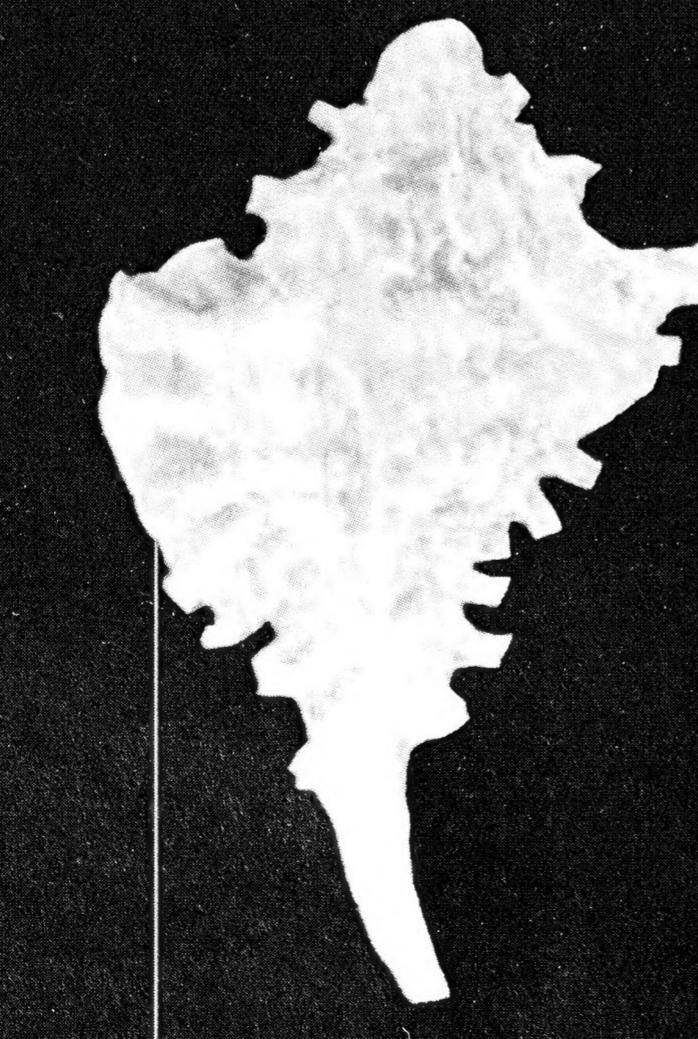
*Murexiella hilli*  
Petuch, 1987



*Murexiella leonardhilli*  
Petuch, 1987



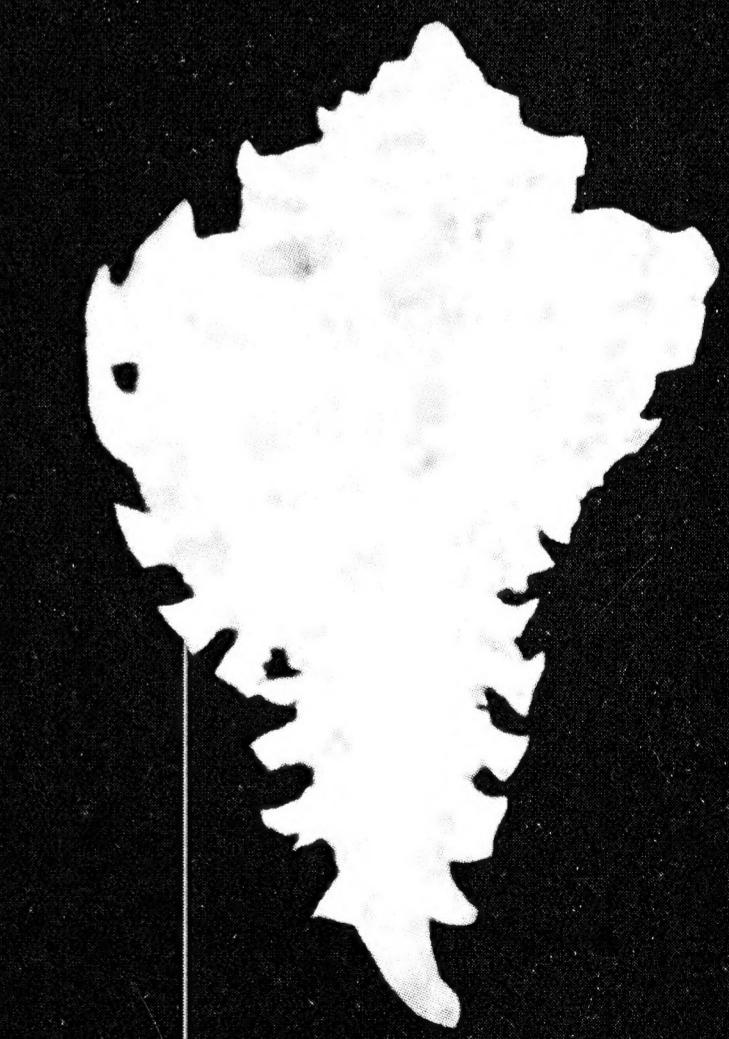
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